Mining and smelting of lead were instituted on a small scale some 18 miles south of the Mission, and thus after more than three-quarters of a century mining, begun and abandoned by the Spaniards, re-entered the scene. The entire project—agriculture, mining, and the education of the Paiutes—was far from successful, and in 1857 the settlement was abandoned. Its failure was speeded by the growing trouble between the Mormons and the U. S. Government which resulted in the recall of settlers to the Salt Lake area. However, the buildings remained to be used by traders and by the carriers of the Overland Mail, and during the Civil War infantry and cavalry were stationed there to guard the route to Southern California. Soon after the withdrawal of the Mormons the land and water rights were largely taken up as a succession of non-Mormon ranches—ranches which are in operation today, some of them in the ultra-modern form known as the "dude ranch." The mining activities started by the Mormons grew slowly in the surrounding desolate country to culminate in the general, but short-lived, mining boom of the early 1900's. Many of the "boom towns," such as Beatty and Rhyolite (Fig. 1), were located at varying, but considerable, distances from Las Vegas; however, Las Vegas was the general service center for many of them, even when they lay outside the "Boulder Dam area," and, hence, "Vegas" grew as they prospered. As a definitely and permanently established town Las Vegas came into existence in 1905. Just as it owed its earlier being to a line of transport, likewise this new phase of its existence, related still to water supply, ties in with the coming of a more modern transportation development, in this case the railroad. The San Pedro, Los Angeles, and Salt Lake Railroad (now part of Union Pacific) purchased a town site, and a true town, replete with town lots, streets, and water systems, sprang up from the desert shrub. The rail line from Salt Lake was completed in 1905, and the Las Vegas and Tonopah Railroad, tapping the country to the northwest, appeared a year later. In 1909 Las Vegas assumed its present role of county seat for Clark County. Two years later, by act of the legislature, it became a city (Fig. 7). But again, as in the days of the Mormon Mission, these transformations were confronted with many difficulties. In 1910 a torrential rain, flooding through Muddy River Valley to the north, wiped out more than 100 miles of railroad south of Caliente (Figs. 1, 2). Service was not re-established until five months later. Hard times, reflecting the importance of the railroad, ensued, and Las Vegas was for a while practically on the West's long roster of "ghost towns." Mining and stock raising in the surrounding region likewise had their

FIG. 6. MESQUITE DRY LAKE

A CLOSE-UP OF A TYPICAL PLAYA SET BELOW THE GENTLE SLOPE OF THE ALLUVIAL PIEDMONT AND FAR BELOW THE MOUNTAIN RIM. NOTE EXTREME FLATNESS OF THE MUD-CRACKED FLOOR OF THE PLAYA.

ups and downs over the ensuing years. The Las Vegas and Tonopah Railroad was abandoned in 1918. Today its roadbed is still utilized, but now as a base for a modern highway. Then, finally, when it appeared that removal of the Union Pacific railroad shops from Las Vegas would again seriously undermine the economic base of the city, the Boulder Dam project, with all its concomitants, burst on the area to give the city a new and different lease on life. The signing of the first construction contracts in 1930 marks a new era in the desert transformation.

While all this was happening to the Las

Vegas portion, approximately the same sorts of things were taking place in some other parts of the region. Mormon settlements were established in the Virgin river and Muddy river valleys, to the north, along or near the line of the Mormon Road. As in the case of the Las Vegas Mission, the emphasis was on agriculture, and here also abandonment followed by later resettlement occurred. Today these settled sections form "strip oases" along the Virgin and the Muddy, producing export crops in the form of melons, vegetables, turkeys, etc., which travel by truck over broad paved highways to both near and distant markets. The Moapa Valley (the lower portion of the Muddy river valley), unlike the Virgin river valley, is served by a railroad tentacle from the main line of the Union Pacific (Fig. 2). Here again Boulder Dam finally enters the picture as a modifier, for the reservoir created by its construction has now covered the lower sections of these agricultural areas and has forced the abandonment of the Mormon villege of St. Thomas (Fig. 2).

The above-noted elements in the changing scene, as at and around Las Vegas and in the Virgin and Muddy river valleys, took place west and northwest of the Colorado gorge. The eastern and southeastern portion of what is now the Boulder Dam area was more isolated and less known, especially the territory stretching eastward to the Grand Canyon country (Figs. 1, 3). However, in the gorge itself there was an interesting, and at least temporarily important, development which paralleled in time the happenings already described. In 1857 a small steamboat ascended the Colorado River to approximately what is now the site of Boulder Dam (Figs. 1, 3). Two years later the Mormons of the Moapa Valley established a landing, known as Fort Callville, on the west bank of the river about due east of Las Vegas. This marked the up-river limit of navigation as carried on for several years—carried on even with ports as far removed as San Francisco. A report of 1868 indicated a trade beween the navigable section of the Colorado and the port of San Francisco of some $1,500,000 for a six-month period. In 1869 Major Powell made his famous journey down the Colorado through the Grand Canyon and on into the gorge section of the Boulder Dam area, and Powell's reports did much to stimulate interest in the region. But, in spite of these activities, the gorge section was left almost unchanged until Boulder Dam came.

Thus, among the man-induced changes as found in the region up to approximately the year 1930, the part played by the Indian proved a relatively insignificant one, while that of the white man assumed considerable importance. Inconspicuous Indian trails had become well-marked trails, trails became roads, and some roads have become highways which are segments of transcontinental routes (Fig. 1). Foot travel changed to horseback travel, horseback travel gave way partially to team and wagon, the stagecoach appeared on the scene, to be followed, at about the turn of the century, by the railroad; the railroad still hangs on but it has lost some of its strength as its services are taken over more and more by the modern desert vehicle, the automobile. It is difficult to overemphasize the part played by the automobile. Whether for pleasure or business, it has become king of transport, both intra- and interregionally. With the automobile have also come tourists and with them money, and money from outside sources often means the difference between life and death for many a desert area. The effects of the automobile, as reflected so importantly in this area by the tourist trade, were being felt shortly before the coming of Boulder Dam, but it has been the dam itself which has "boomed" the trade and caused persons to tarry long enough to spend truly significant sums of money in the region.

Along with the evolution of the routes and the carriers went an evolution in settlement. Waterholes largely dictated the settlement sites and, hence, to a degree the general alignment of the routes. Indian hut and pueblo ruins gave way to stockaded posts and spots and strips of oasis agriculture; mining camps, often soon to be "ghost towns," sprang up in the most unpredictable positions; a scattering of ranches, their number curbed by aridity as reflected in scarce water and sparse feed for stock, lost themselves in the broad desert sweep; and finally, the posts

Fairchild Aerial Surveys photo, 1932

FIG. 7. LAS VEGAS, NEVADA

THE LINE EXTENDING FROM CENTER LEFT TOWARD THE UPPER RIGHT CORNER IS PART OF THE MAIN RAILWAY BETWEEN LOS ANGELES AND SALT LAKE CITY. THE CHARLESTON MOUNTAINS APPEAR IN THE LEFT BACKGROUND.

became permanent towns and villages and one of them, Las Vegas, took on the aspect of a city. All of this took place before the construction of Boulder Dam. Granted this, it is still true that the dam has caused an acceleration in cases where progress was being made and has stopped or slowed down the forces of retrogression in others. These things cannot be accurately measured, but certain it is that obliteration of Boulder Dam would largely destroy the present economic base. To grasp the real import of this it is necessary to see what changes the dam has actually brought.

The coming of Boulder Dam might be said to be purely fortuitous. Its advent represented no need or demand within the area but rather the needs and demands of other regions, most of which are far removed (Fig. 1). The lower Colorado Valley flooded; certain down-river sections wanted a steady, rather than a spasmodic, supply of water for irrigation; the ever-growing Los Angeles area desired more water and more cheap hydroelectric power; so, finally, a vast project as set up by the Swing-Johnson Bill came into being on paper in 1928. The spring of 1931 saw the first excavation, water storage began in the late winter of 1935, the first hydroelectric power was generated in the fall of 1936, and the summer of 1941 witnessed the world's largest reservoir filled to capacity. Meanwhile many things have happened to modify the desert region which lies contiguous to the dam and the reservoir —things which would never have happened were it not for the fact that sufficient control of the Colorado's waters forced the choice of the site for the dam far upstream into the gorged section of the valley, hence, far removed from the areas which supposedly were the major beneficiaries of the Boulder Canyon Project Act.

When reference is made to the changes brought about by Boulder Dam, it is often forgotten that the dam represents no mean transformation in and of itself. Wedged across the upstream section of the Black Canyon gorge of the Colorado (Figs. 8, 9), it rises higher from its base than any other

dam in the world. With a volume exceeding that of the Great Pyramid, it reaches upwards 726 feet, is 660 feet thick at the base, and tapers to 45 feet thick at the crest. Yet, despite these dimensions, it is dwarfed by the still higher walls of Black Canyon and by such nearby features as Fortification Hill.

The major physical feature resulting from the construction of Boulder Dam is the Lake Mead reservoir (Figs. 3, 8, 10), which, paradoxically, is now the world's largest artificial lake existing in one of the drier sections of the earth. Unlike the dam, Lake Mead is not dwarfed by the contiguous natural features. (For reasons of security the publication of aerial photographs to reinforce this point is not allowed at this time). Here, again, some figures are necessary to portray the degree of transformation that has occurred. Lake Mead is about 115 miles long and varies in width from a few hundred feet in the gorge sections to 7 or 8 miles in the more open portions; its depth at the dam is nearly 600 feet and even upstream as far as the Virgin river reservoir-arm (the largest northern extension) it is more than 500 feet deep; in area it represents some 227 square miles of water surface. At capacity Lake Mead holds enough water to cover the entire State of Connecticut to a depth of 10 feet and enough to supply New York City for twenty years; and all this in a region where a single small spring has often meant the difference between life and death, a region that receives an average annual precipitation of but 5 or 6 inches and which in some years may receive less than 2 inches. The Lake Mead reservoir controls three-quarters of the run-off of the Colorado basin and can contain at one time a full two-year's flow of the river. Upstream from the head of the reservoir the Colorado still runs uncontrolled but as it enters the narrow, walled head of the reservoir its muddy flow is checked and the water changes from the brown of the canyon torrent to the clear blue of the lake. Underneath the lake surface the silty flow continues as "another kind of river" flowing slowly and muddily along the old channel of the Colorado. Estimates vary widely, but it seems probable that it will take at least 200 years for this "mud-river" to fill the reservoir to the point where its efficiency is destroyed, and before that time it is entirely possible that ways will be found to lead at least part of this mud-stream through lower conduits in the dam. Downstream from the dam, where formerly the river carried an average silt load of 300 tons per minute through Black Canyon, the controlled stream now flows clear. In fact it has so little load at present that it is beginning to scour its former deposits and thus cut a new gorge into a more ancient one.

FIG. 8. BLACK CANYON AND PART OF LAKE MEAD

LOOKING UPSTREAM FROM THE CREST OF BOULDER DAM, FORTIFICATION HILL IS SEEN IN FAR BACKGROUND

Accompanying the clarity of the waters directly below the dam is the establishment of uniformly cool water temperatures, for the released water is drawn not from the surface of Lake Mead but from depths of 150 to 300 feet. As a result the Colorado is now a trout stream for some distance downriver from the base of the dam. Above the dam, the reservoir has been stocked with millions of fish (bass, crappie, catfish, perch) and, in addition, its surface constitutes a tremendous wildfowl refuge located along one of the major migration lines. Thus, as part of the transformation of the area, the building of the dam has resulted in the covering of more than 200 square miles of desert surface with water, has changed the behavior of water and silt movement, radically modified the conditions of aquatic life, and, in addition, furnished a water supply for the nearby new settlement of Boulder City (Figs. 2, 12).

Another important element in the evolution of the country at, and in the vicinity of, the dam is the creation, or in some cases the modification, of transportation lines. To provide a flow-line for materials for the building of Boulder Dam and Boulder City a new railroad was constructed from the main line of the Union Pacific. This line begins at Boulder Junction just south of Las Vegas, extends southeasterly across the Las Vegas basin, pushes through the basin rim via Railroad Pass (Fig. 11), and then turns easterly to the railroad yards at Boulder City, from which point it makes a winding descent of more than 1000 feet into the western side of Black Canyon at the damsite (Fig. 2). Somewhat counterbalancing the creation of this approximately 35-mile tentacle, the flooding of the Virgin river arm of the reservoir, on the north, has caused the removal of about five miles of track from the spur line that serves the Moapa Valley. Another phase of change in relation to the railroad is an increase in passenger traffic on the main line of the Union Pacific through Las Vegas because of rail-tourists visiting Boulder Dam and Lake Mead. This does not, however, affect the spur-line to the dam, mentioned above, inasmuch as such passengers are transferred to busses at Las Vegas. Likewise, busses handle the same type of traffic flow from the main line of the Sante Fe at Kingman, Arizona, even though Kingman is some 80 miles southeast from the dam and is, in any strict sense, outside of the Boulder Dam area (Figs. 1, 2).

FIG. 9. BLACK CANYON AND THE COLORADO LOOKING DOWNSTREAM FROM THE CREST OF BOULDER DAM. THE DEPTH OF THE GORGE CAN BEST BE APPRECIATED BY REMEMBERING THAT THE CREST OF THE DAM IS ITSELF FAR BELOW THE TOP OF THE CANYON.

Of much greater importance than the effect on railroads is the effect on roads. Already existing roads have seen a tremendous spurt in automobile travel, and this is especially true of the transcontinental highway that passes through Las Vegas on its way from Salt Lake City to Los Angeles (Fig. 1). This road is the modern equivalent of the Old Spanish Trail whose course it at least approximates. Also, at about the time that the activities associated with the Boulder Dam construction began, Death Valley, to the west (Fig. 1), was coming into real prominence as a resort area, and these two factors working together helped to cause the modernization of, and the increased flow of traffic on, the Las Vegas-Death Valley road. Further information on the role of Death Valley is given by the author in the July 1940 issue of *Economic Geography*.

Even more important has been the creation of new roads where none previously existed. Most pertinent in this connection is the truly modern highway that now connects Las Vegas and Kingman. Certainly here is a change in the picture that no one would have even thought of a few years ago. With a rugged, parched, and nearly uninhabited

land split in twain by the practically impassable gorge of the Colorado a more or less direct-line highway between southeastern Nevada and northwestern Arizona seemed quite out of the question (Fig. 3). Then, suddenly, came the need for a first-class road from Las Vegas to what was soon to be Boulder City and Boulder Dam. When the dam had bridged the canyon, the highway was continued, making use along part of the route of sections of poor ranch and mine roads in Detrital Valley (Fig. 3), and now a broad paved highway leads directly into Kingman. This has the important result of cross-linking two of the major routes of western travel: the Sante Fe-Los Angeles highway and the Salt Lake-Los Angeles highway. In addition, it also ties in as part of a wide circuit around the entire Grand Canyon (Fig. 1). As in the case of the railroads, there has been a minor deletion of a few miles of lesser roads as a result of the filling of the reservoir in the lower Virgin and Moapa Valleys and in a few other places as, for example, the northern end of Detrital Wash. But unlike reservoirs that have been created in rather densely settled humid lands, Lake Mead has not appreciably disrupted the existing road system; rather, as pointed out, the entire project has had the opposite effect.

Another kind of road has also been added to the circulatory system of the region, in this instance the water road as opposed to the land road. Because of Lake Mead it is now possible to travel by boat literally into the lower gorge of the Grand Canyon and into other sections which were hardly less accessible a few years ago. As a result, vast areas are now open to the scientist and the tourist, where before 1930 a mere handful of men had been able to penetrate, and some had penetrated never to return. It is as if a portion of the Lost World had been suddenly placed on the doorstep of civilization. To fulfill the ever-growing demand for lake travel a year-around boat service is operated from the Hemenway Wash embayment of Lake Mead (just northwest of the dam) with local trips to the upstream face of the dam and longer trips to the Virgin River section and the Grand Canyon, the latter representing a round trip distance of about 200 miles. Beside the regular boat service there are already (1941) nearly 300 privately owned small craft in use on Lake Mead.

Even in the roads of the air there has been some transformation which correlates with the coming of Boulder Dam and Lake Mead. The Las Vegas airport has seen an increase in both private and nonprivate plane traffic, a portion of which is attributable to factors associated with the dam and the lake, and at Boulder City a newly created airport serves private planes as well as furnishing daily service via commercial air lines.

Thus, on land , water, and in the air, lines

FIG. 10. AN ARM OF LAKE MEAD NORTH OF BOULDER CITY
MILLIONS OF GALLONS OF FRESH WATER IN THE STRANGE ARID SCENE. THE VIEW IS TOWARD THE NORTHEAST.

Fairchild Aerial Surveys photo

FIG. 11. RAILROAD PASS AND THE LAS VEGAS BASIN

LOOKING NORTHWEST ALONG THE STRAIGHT LINE OF THE HIGHWAY, LAS VEGAS IS LOST IN THE DESERT HAZE AT THE END OF THE ROAD. THE PASS IS THE ONLY EASY ROUTE FROM LAS VEGAS BASIN TO BOULDER CITY (SEE FIG. 3 FOR LOCATION). THE MORE CURVING LINE WHICH CROSSES THE HIGHWAY AT THE PASS CREST IS THE GOVERNMENT-OWNED RAILWAY WHICH BEGINS JUST SOUTH OF LAS VEGAS AND ENDS AT BOULDER DAM ITSELF. NOTE, IN CENTER LEFT AND IN IMMEDIATE FOREGROUND, THE FLOOD PREVENTION WORKS FOR THE PROTECTION OF THE RAIL LINE FROM THE "FLASH-FLOODS" SO CHARACTERISTIC OF THE DESERT LANDS. TO BRING THIS PICTURE UP TO DATE THE LARGE BUILDINGS AND THE MODEL HOUSING OF BASIC MAGNESIUM INC. SHOULD APPEAR BEYOND THE CENTER OF THE PICTURE ALONG THE HIGHWAY AND ON TO WHERE THE RAILROAD BENDS TOWARD THE HIGHWAY.

of movement of persons and goods have been affected, or created, to provide a modern part of the changing desert complex. These routes, whether roads, railroads, and so on, are dead things, yet they aid in the maintenance of life to the degree that they serve as veins and arteries which connect settlement with settlement, settlements which in the Boulder Dam area range from isolated ranches and mines to Las Vegas and Boulder City.

Just as the coming of Boulder Dam has played a vital part in the present-day expressions of lines of transport, likewise it has brought recent and important changes in regard to settlements and population. Perhaps the most conspicuous element in the evolving settlement picture was the "overnight" establishment of a full-fledged town in a barren, rocky, and isolated section that normally would be incapable of supporting even a handful of persons. This settlement, the planned town of Boulder City, came into being in 1932 to serve the needs of the thousands of persons working on Boulder Dam. It is located about 7 miles southwest of the dam on the higher and more level country west of the Black Canyon Gorge, where summer temperatures are somewhat cooler and where the terrain allows the establishment of

Fairchild Aerial Surveys photo, 1932

FIG. 12. BOULDER CITY, NEVADA

LOOKING EASTERLY ACROSS THE BLACK CANYON GORGE IN WHICH BOULDER DAM IS LOCATED. THE DARKER ROCK FORMATIONS MARK THE TREND OF THE GORGE. THIS VIEW, TAKEN IN 1932, SHOWS HOW THE PLANNED GOVERNMENT TOWN HAS SPRUNG FROM THE DESERT WASTE. THEN A "CONSTRUCTION TOWN," IT IS NOW A PERMANENT AND ENLARGED CITY ADDING GOVERNMENT AND TOURIST-CENTER FUNCTIONS TO THOSE OF AN ORDINARY CITY.

a regular plan not too stringently controlled by the topography (Fig. 12). No longer a construction town, it has acquired a permanent status as the home of men who operate and maintain the dam, the powerhouses, and the entire reservoir property, and as such it has a nontransient population of about 3000 persons (1941). Being permanently established, and being where it is in reference to Boulder Dam, Lake Mead, and the modern transportation systems, it has also taken on the job of an important tourist and recreation center; thus, mixed in with what might be termed the "Government town" is the town of numerous restaurants, automobile service stations, tourist courts, hotels, stores, and all the other elements that go with a heavy flow of persons and automobiles along the highway. The heaviness of this flow, and hence its effect on Boulder City, may be given a necessary recognition by pointing out that in the 17 months preceding September, 1941, about one and one-fifth million persons passed through the town and nearly all of them contributed in some degree to its upkeep.

Indicative of still further, and likewise recent and rapid, transformation of the settlement picture is the coming of "another Boulder City." This town, called locally "Basic Magnesium," is in connection with the establishment of what is reputed to be the largest single magnesium plant in the world. Begun just previous to the participation of the United States in the present war, this magnesium plant represents a financial outlay of $133,000,000. Located just south of the main highway between Las Vegas and Boulder City, about ten miles southeast on the outskirts of "Vegas" itself, this town even in its initial development represented a settlement of several thousand persons (see latter part of explanation which accompanies Figure 11). Drawing on Boulder Dam power and reaching, in this instance, far northwest to the vicinity of Luning, Nevada, for ore supplies (Fig. 1), this development has added a new, and again virtually un-

predictable, modification of desert brush and rubble.

Supplemental to these major elements in the matter of *new* settlements are several minor ones which should not be ignored. Along the highways leading out of Las Vegas, especially along the route to Boulder Dam, there has been a mushrooming of small buildings and clusters of buildings serving as restaurants, gasoline stations, taverns, tourist courts, etc. Likewise, and even considerably removed from Las Vegas and Boulder City, similar new services have appeared here and there along the main traveled roads as the dam has encouraged heavier and heavier tourist flow. Also, under the control of the National Park Service, carefully planned and supervised small settlements are being established here and there on the Lake Mead shore, both near the dam and near the extreme head of the reservoir, as at Hemenway Wash and Pierce's Ferry. In some cases, as near the dam, a variety of functions are represented, including boating, bathing, camping, fishing, and housing. In other cases they are merely isolated fishing camps as, for example, the one at the end of the road next to the junction of the Muddy and Virgin river arms of the reservoir.

Of the settlements extant at the birth of the Boulder Dam project, Las Vegas has been most affected; its modification being second only to the outright creation of Boulder City. In fact, as stated above, the project actually saved Las Vegas from a serious decline. To be sure, other factors have been operating simultaneously. Las Vegas is now a divorce, marriage, and gambling center; also it serves as a base for recreational use of parts of the high Charleston Mountains near Charleston Peak (Figs. 2, 3). However, all these are more or less directly connected to Boulder Dam and Lake Mead—granted a combination of factors, it is, nevertheless, a combination in which Boulder Dam is not only the key ingredient but a catalytic ingredient as well. There are certain indicators which support this contention. For example, the number of tourists visiting the area in 1930, the year before construction of the dam began, was slightly more than one-tenth of a million, whereas in 1940 the number was about two-thirds of a million. This great number is now (as of September, 1941) reflected in Las Vegas by 45 auto courts, 40 hotels and rooming houses, 25 garages, and 28 service stations. Major payrolls in the area also reflect the situation. They are per month for Clark County (1940): mines $60,000, railroad $90,000, City of Las Vegas $100,000, and Boulder City $200,000. When it is remembered that Las Vegas is the county seat, the chief commercial center, and the major recreational unit, the connection between it and the Boulder Dam payroll is fairly obvious. Regardless of the exact weighting to be given the effect of the dam of Las Vegas, it is significant to add that the city's population has approximately tripled since the dam came into the picture (1941 nontransient population was about 10,000). How much money has been provided this increased population of Las Vegas by the approximately 5,000,000 persons who have so far visited Boulder Dam is impossible to say; however, it amounts to many millions of dollars and represents the difference between a large and thriving desert center and one that is dwindling and nonprosperous.

A CENTURY AT THE SEASHORE

By JOEL W. HEDGPETH

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UNTIL a hundred years ago the seashore, with all its myriads of nameless creatures, had been left to itself. It had remained, almost since the beginning of time, as Sir Edmund Gosse described it:

> The rocks between tide and tide were submarine gardens of a beauty that seemed often to be fabulous, and was positively delusive, since, if we delicately lifted the weed curtains of a windless pool, though we might for a moment see its sides and floor paven with living blossoms, ivory white, rosy-red, orange and amethyst, yet all that panoply would melt away, furled into hollow rock, if we so much as dropped a pebble in to disturb the magic dream.

To be sure, naturalists had known of this vast and lovely province of nature since the days of Aristotle, that first great seashore observer, and there had always been collectors of such conspicuous things as sea shells and starfishes as well as fishers of crabs and cockles for the market place, but in all those hundreds of years between Aristotle and the early years of Victoria's reign there had been no general pillage of the seashore.

Today, however, there is no longer peace at the seashore, except, paradoxically, in areas which have been restricted in wartime. The "unravished bride of quietness" has been ravished by those very ones who profess to love her most, the nature lovers and the zoology students. Armed with handsomely illustrated books, buckets, bottles, and enamel pans, they descend upon the shore left undefended by the recessed tide, and scrape its creatures from their rocky homes and dig them out of their crevice refuges. Reefs which have been particularly favored by the complicated circumstances of time, tide, and temperature, have suffered the most, especially if they are near cities, and it is the perennial lament of the teacher who guides another ravaging horde to a choice "collecting ground" that the beach is no longer as it used to be ten, fifteen, or twenty years ago. Perhaps there has been, he suggests, a shift in the ocean currents, and the rarer creatures have been obliged to seek some more favorable spot.

It may be unfair to accuse any one person of bringing this lamentable state of affairs to pass, but if we trace the development of seashore study, at least as an amateur pastime, to its beginnings, the most influential name we find is that of Philip Henry Gosse. There are others, notably Louis Agassiz, who discovered the seashore shortly after his arrival in America in 1846, who did their share in promoting the study of the seashore, but it is Gosse who seems to have inspired the greater part of the host of dilettante and amateur collectors who have invaded the beaches in the past hundred years.

As his son Edmund tells us in *Father and Son*, that inimitable psychological "study of two temperaments":

> The fairy paradise has been violated, the exquisite product of centuries of natural selection has been crushed under the rough paw of well-meaning, idle-minded curiosity. That my Father, himself so reverent, so conservative, had by the popularity of his books acquired the direct responsibility for a calamity that he had never anticipated, became clear enough to him before many years had passed, and cost him great chagrin.

Philip Henry Gosse, the man who, in the words of the Reverend Charles Kingsley, himself the author of *Glaucus*, an immensely popular seashore book, did "more for the study of marine zoology than any other . . . man," happened to take up his calling of popularizing the seashore by accident. It was in 1843, just after Sir James Ross had returned from his Antarctic voyage, and when the theories of Edward Forbes about the distribution of life in the sea were much in the minds of professional naturalists. Gosse, then 33 years old and author of a not too successful book, *The Canadian Naturalist*, was engaged in writing a general zoology for the Society for Promoting Christian Knowledge when an illustrator named Whimper suggested that a book about the ocean might find a ready sale. The project appealed to Gosse, and some time in the following year he completed the book, and it

appeared in 1845 while he was in Jamaica on a collecting trip.

This book, *The Ocean*, is the first of that long series of volumes, many of them lavishly illustrated, on the wonders and mysteries of the deep. It is a rare secondhand bookstore that does not have two or three of these in stock—the recent ones, prepared for this more sophisticated age, cannot compare with those older volumes, crammed with woodcuts and fascinating stories of everything from the unfathomable mysteries of the great abysses to the elusive Flying Dutchman. Sea serpents, of course, received extensive mention. But it is vain to attempt to describe one of these wonderful books. The eager reader is advised to seek them out in the dustier recesses of a secondhand bookstore.

Gosse not only set a new style in books but also changed his own life, for he was the first person to be influenced by his own book. The interest in marine zoology he had acquired while preparing *The Ocean* led him to further studies, and in a few years he published his *Naturalist's Rambles on the Devonshire Coast* (1853), which is an account of the manifold attractions of the seashore, beautifully illustrated by his own drawings. Since the appearance of this book it has become the tradition for writers on seashore life to be their own illustrators, but in precision of detail and brilliance of color Gosse's illustrations for the *Devonshire Coast* have seldom been equaled in any work, whether it be a scholarly monograph or popular handbook. The book not only established Gosse's reputation as an interpreter of the life of the seashore, which was eventually to earn him an F. R. S. to attach to his name, but also it almost immediately started a new fad in parlor amusements, the marine aquarium. Perhaps it was this fad which had as much to do with the ravishing of the seashore, which his son was to deplore fifty years later, as the more conventional gathering of crabs and sea shells for the collector's cabinet. In one season alone Gosse himself collected more than 4,000 specimens for exhibition in his aquaria at museums. Gosse was also the first, at least in England, to hold natural-history classes on the seashore.

Of course, this interest in seashore life was not entirely inspired by Gosse's books and activities. Edward Forbes, the Manx naturalist, also was a familiar name to amateur naturalists through such works as his charming *History of British Starfishes* (1841) and his posthumously published *Natural History of the European Seas* (1859). But we remember Forbes primarily because of his great mistake, his theory that animal life did not exist in the ocean below 300 fathoms. This error, together with his

PHILIP H. AND EDMUND GOSSE
FROM EDMUND GOSSE'S BOOK *Father and Son.*

pioneer classification of marine life by zones, stimulated dredging activity by professional and amateur alike off the shores of Britain, Norway, and the eastern United States.

Although it would be difficult to prove such a supposition, it seems probable that Forbes and Gosse were more responsible for that first great oceanographic expedition, the voyage of the *Challenger*, than posterity has seen fit to acknowledge. Certainly these two men, as diverse in character and personality as it is possible to imagine, stimulated the large followings of British natural-

EDWARD FORBES
FROM WILSON & GEIKIE'S LIFE OF EDWARD FORBES.

ists which were to encourage and support the *Challenger* Expedition.

Edward Forbes was not so fortunate in his biographer as was Philip Henry Gosse, and as a result his personality has been lost in the arid bypaths of the history of science.[1] Of Gosse's almost pathological Calvinism, his fantastic efforts to reconcile his own literal interpretation of God's Word with the fossil record, as expressed in that odd book *Omphalos, or The Geological Knot Untied*, which so shocked Charles Kingsley that he protested that if anything could make him doubt God's wisdom it was that book—of these things, and what they meant to a sensitive, growing boy, we have a beautifully written record.[2]

Edward Forbes, on the other hand, was a completely charming character. Indeed, he was one of the most delightful personalities that ever graced the solemn halls of science. During those years when Charles Darwin was patiently studying his barnacles every morning and Thomas Henry Huxley was cruising off Australia in H.M.S. *Rattlesnake*, Edward Forbes was the great name on the roster of British naturalists. When anything was afoot, it was Forbes who was consulted, and his approval was eagerly sought by the younger naturalists, including Huxley. Gosse, on the other hand, was a lonely and solitary man, especially after the cool reception—or lack of reception altogether—accorded to his *Omphalos*. Friendship, for a man so beset by his own thorny theology, was difficult at best, and even his intimacy with the genial and easy-going Forbes was a short-lived affair.

Forbes never forgot that he was born on the Isle of Man. If he did not believe in the Little People, he was at least very considerate of their feelings. Gnomes, leprechauns, mermaids, and nymphs frequented the margins of his student notebooks and occupied conspicuous places in the chapter headings and tailpieces of his monograph on starfishes. During scientific meetings his long fingers were always busy drawing caricatures of the speakers or writing accounts of the meeting in humorous verse—with dubious rhymes—to be read later at his own Red Lions Club. His tall, thin frame was accentuated by long hair which hung loosely below his ears, and his deep-set eyes and broad mouth betrayed his Celtic ancestry. Forbes died in 1854, shortly after he had gained the chair of natural history at Edinburgh for which he had waited so long and impatiently. Though he was busy in his chosen field for most of his forty years, Forbes left no extensive monument of books and papers behind him. His influence was felt primarily through personal contact and lectures. His oft-expressed theory that the distribution of living animals and plants could best be understood by comparison with related fossil forms entitles him to an honored but seldom acknowledged place as one of the founding fathers of paleontology.

Forbes was less fortunate than Gosse in his family. Gosse, like Henry Moseley, the mathematician of sea shells and designer of battleships, whose son was H. N. Moseley, naturalist of the *Challenger*, and whose grandson was H. G. J. Moseley, the brilliant physicist who was killed at Gallipoli, and like Thomas H. Huxley, founded one of those three generation dynasties which have contributed so much to British science and culture. For Gosse's son Edmund, in spite of his being raised in a home where Shakespeare was frowned upon as frivolous, be-

came one of "the most understanding and sympathetic interpreters of literature," and his grandson Philip is a recognized authority on radium as well as the author of several books about piracy. Forbes had two children, but neither the *Dictionary of National Biography* nor those concerned with the later misadventures of Mrs. Forbes—including the usually exhaustive William Roughead—have found them worth mentioning. For in 1858, four years after the death of Professor Forbes, his widow contracted a marriage which, to put it mildly, was unfortunate, and the subsequent turmoil may have been the prime factor in denying a line of Forbeses to British science. The man Mrs. Forbes had the misfortune to marry was one William Charles Yelverton, who, it seems, had already informally married himself to a Miss Longworth under circumstances of questionable legality. During the ten years controversy over this marriage, which included debates in the House of Lords, poor Mrs. Forbes and her two children became the innocent and forgotten bystanders.[3]

CONTRARY to the impression which might be gained from a glance at the shelves of a well-stocked library, there have been relatively few good books on the seashore and marine natural history since Gosse's day. There has been no dearth of hack works, many of them charming in an unconscious way, and of serviceable manuals for amateurs, but within the rigid limits of the genre Gosse has had no successful imitators until the past twenty years. Two of the best are *The Seas*, by F. S. Russell and C. M. Yonge, and D. P. Wilson's *Life of the Shore and Shallow Sea*. Both of these are by members of the staff of the Marine Biological Association Laboratory at Plymouth. These two books satisfy the three essentials for a book of this type: that the author should be a recognized authority, that he should illustrate the book—at least in part—himself, and that it should be written in language accessible to the layman. A further desideratum, suggested by the influence these books have had on seashore collecting, might be that they should inspire respect for life and discourage idle collecting while at the same time arousing interest. Unfortunately, such sentiments are rarely expressed.[4]

Although the Woods Hole Marine Biological Laboratory antedates that of Plymouth by several years and has established an honorable tradition of marine research in America, no member of its staff has prepared anything comparable with the two recent English books. Some explanation for this may lie in the very size of the United States, its diverse ocean fronts, and the reluctance of commercial publishers to venture on projects which have only local interest, but none of these possibilities is altogether valid since at least two fine books, both of them about the Long Island shore, have been published in recent years. These are William Crowder's *A Naturalist at the Seashore* (1928) and H. J. Shannon's *The Book of the Seashore* (1933). The authors are both accomplished illustrators but are essentially amateur naturalists.

Only on the Pacific coast has a book appeared which might be considered to stand in the high tradition of English popularization. This is *Between Pacific Tides*, by Edward F. Ricketts and Jack Calvin (1938). Though intended as a handbook for seashore animals of the Pacific coast, its readable style and approach to the problem by zones instead of zoological classification raise it far above the usual status of a handbook. This book has a sort of sequel, *Sea of Cortez*, by John Steinbeck and Edward F. Ricketts, which is something else again. Many have found its narrative half too philosophical for their tastes or have objected to the philosophy on its own merits.

But it is not these books alone which send students and dilettantes to the seashore to continue that pillage which Gosse did so much to inspire less than a hundred years ago. Indeed, such books are probably not consulted until interest has already been aroused in some other manner. This has been more true, perhaps, in America than in England, where, despite the paucity of good seashore books, the coasts of Massachusetts and California have been as effectively raided as that of Devon, and the primeval beauty of the seashore is no more. It is no less a personage than Louis Agassiz who must be blamed for a large share of

the impetus which sent well-meaning despoilers to the shores of the North American Continent. Like that of Forbes in England, the influence of Agassiz has made itself felt through teaching and the inspiration of teachers rather than through the writing of books, and the precept "Study nature, not books," which he posted on the wall of America's first seaside station at Penikese in 1873, is still fresh in the minds of American naturalists (now called biologists, or worse still, ecologists), professional and amateur alike.

They have indeed studied nature instead of books, although some of them seem to have conducted their studies solely for the purposes of contributing rather dull and detailed monographs, if not the writing of books. Looking over the first hundred years of the books—seaside companions and vade mecums, as few as they are, one is tempted to deny that there is any need for newer and better books about the fascinations of the seashore and its creatures. The writer, himself an ardent student of one type of littoral creature, whose numbers he has persistently reduced on every occasion he has visited the beach, and furthermore the author of some popular articles which may have done their own small part to promote that same enthusiasm he now deplores, fully realizes that he is not without sin. Yet up-to-date manuals of seashore life are badly needed, even at the peril of further ransacking of the tidepools. Of course, it might be argued that an obsolescent manual or quaintly outdated book—for example, perhaps, one of Gosse's—stimulates more intensive collecting, and that a complete manual might eliminate the necessity of excessive collecting in the hope of finding uncatalogued rarities.

There seems to be no way out of this dilemma; certainly G. K. Chesterton wrote no truer paradox than "The man who is most likely to ruin the place he loves is exactly the man who loves it with a reason."[5] Such a thought could not have occurred to Aristotle on a visit to the shore in those remote golden days before Everyman became his own biologist, carrying a bucket to the beach, for Aristotle, while not much of a poet himself, had a taste for Homer and loved the sea with emotion as well as reason. The unkindest slur against that great man's name is the fable that he ended his life by throwing himself into the sea because he could not understand the currents in the Strait of Euripus.

We cannot expect a generation of Aristotles, but it does not seem too much to hope for that our biologists, readers and writers of books alike, will go down to the shore, not in the spirit of treasure hunters, but as poets in spirit and as students of living things instead of specimens in bottles, even if the Homeric phrase does not ring in their ears as it surely did in those of Aristotle:

παρὰ θῖνα πολυφλοίσβοιο θαλάσσης.

NOTES

[1] In addition to *Father and Son*, Edmund Gosse wrote an earlier, more formal biography of his father, *The Life of Philip Henry Gosse* (1890). The only biography of Forbes is *Memoir of Edward Forbes, F.R.S.*, by George Wilson and Archibald Geikie (1861). It suffers from being the work of two hands, neither of them skilled in biography.

[2] It is not without its note of irony that Gosse, the author of *Omphalos*, a book which argued, among other things, that the fossils were created *in situ*, was also the originator—or most ardent proponent—of the theory that the sea serpent is a living *Plesiosaurus*.

[3] Cf. William Roughead, *The Evil That Men Do*, vol. 2, "The Law and Mrs. Yelverton," pp. 469–505 (Crime Club, 1929). Perhaps it should be mentioned that H. O. Forbes (1851–1932), author of *A Naturalist's Wanderings in the Eastern Archipelago*, was the son of the Reverend Alexander Forbes, and presumably no relation to Edward Forbes. Forbes's son was born in 1850, but we do not even have his name.

[4] The works of William Beebe, and Rachel L. Carson's *Under the Sea Wind* (1941), are not, strictly speaking, books about the seashore, nor are they illustrated by their authors. Miss Carson's book is further disqualified, by my standards, because it gives names to creatures after the manner of Thornton W. Burgess and is mired down in too many purple patches.

[5] G. K. Chesterton, *Orthodoxy*. Ch. V, "The Flag of the World."

The following vignette is from the title page of Forbes' *British Starfishes*.

In Triton's shell the echoing sea
is but the mirrored surge of sound
within the distant hallways of the ear,
and time the shadow of a thing unfound.

JOEL W. HEDGPETH

BRAZIL'S RESEARCH FOR INCREASED RUBBER PRODUCTION

By NORMAN BEKKEDAHL

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IN AN effort to regain prominence as one of the principal rubber-producing nations of the world, Brazil, in the past few years, has been conducting research and making plans to increase her output of rubber. In the early days of natural rubber practically all of the world's supply came from her Amazon Valley. Unfortunately for that country, however, her natives at that time were making plenty of money by collecting latex from the wild rubber-trees of the jungle and processing it into the form of crude rubber, and thus took no interest in improving any of the processes or steps involved. High prices for the rubber and a lack of competition did not lead them to look into the future.

The British and the Dutch were quick to take advantage of this backwardness of the natives of the Amazon Valley. In the year 1876 Sir Henry Wickham gathered 70,000 seed of the Pará rubber tree, botanically known as *Hevea brasiliensis* Mull. Arg., from the banks of the Tapajós River, close to its outlet into the mighty Amazon. These seed, after germination in England, were transplanted in the Far East and became the beginning of all the rubber-growing industry of that part of the world which ultimately produced 97 percent of the world's supply of rubber.

In 1912 Brazil hit its high in production of rubber, over 40,000 long tons. This accounted roughly for 40 percent of the world's supply at that time. With the great increase in demand and supply which followed in later years, Brazil would have had to produce about ten times that quantity in order to hold the same percentage in 1938, the last normal year before the war.* Instead she actually produced less than 15,000 tons. This decrease in production was caused largely by the fact that rubber produced from wild trees in Brazil by the primitive methods could not compete in price with rubber produced from the planted trees and the more modern processes developed and used in the Far East. The Ford Company started planting rubber trees in Brazil in 1929 but was unable to produce much rubber because of the unforeseen difficulties which will be described later in this article. The last few years, however, have seen an increase in the production of wild rubber in Brazil because of the higher price for natural rubber set by agreement. This price was high enough so that profits could again be realized even with the same old primitive processes used in the Valley over 50 years ago.

Brazilian authorities now realize that if Brazil is to become a large producer of rubber, she, also, must plant and cultivate trees instead of depending on the wild trees of the jungle. If this is to be done there are many problems which must first be solved. It is true that most of the large amount of research performed on the growing and processing of rubber in the Far East will contribute considerably to the solution of problems of this hemisphere too, but because of different conditions much new work needs also to be done in Brazil.

The Hevea tree requires a warm, moist climate in order to thrive. In order to obtain a fairly good yield of latex, the tree must grow within about 10 or 15 degrees of the equator, either north or south. The Amazon Valley, which is the original home of the Pará rubber tree, therefore, has suitable climatic conditions. Over a very large area in the jungles of the Amazon Valley this tree grows wild but scattered. The number of the Hevea trees usually does not average more than two or three per acre.

In Brazil the Pará rubber tree is commonly known as the *seringueira,* and the native who taps the trees for latex and processes it into rubber is known as the *seringueiro.* This *seringueiro* must arise in the early morning hours each day of the week and make a tour of his path, or *estrada,* into the jungles, which has been routed so as to include as many rubber trees as is possible. From 50

RUBBER SEEDLINGS

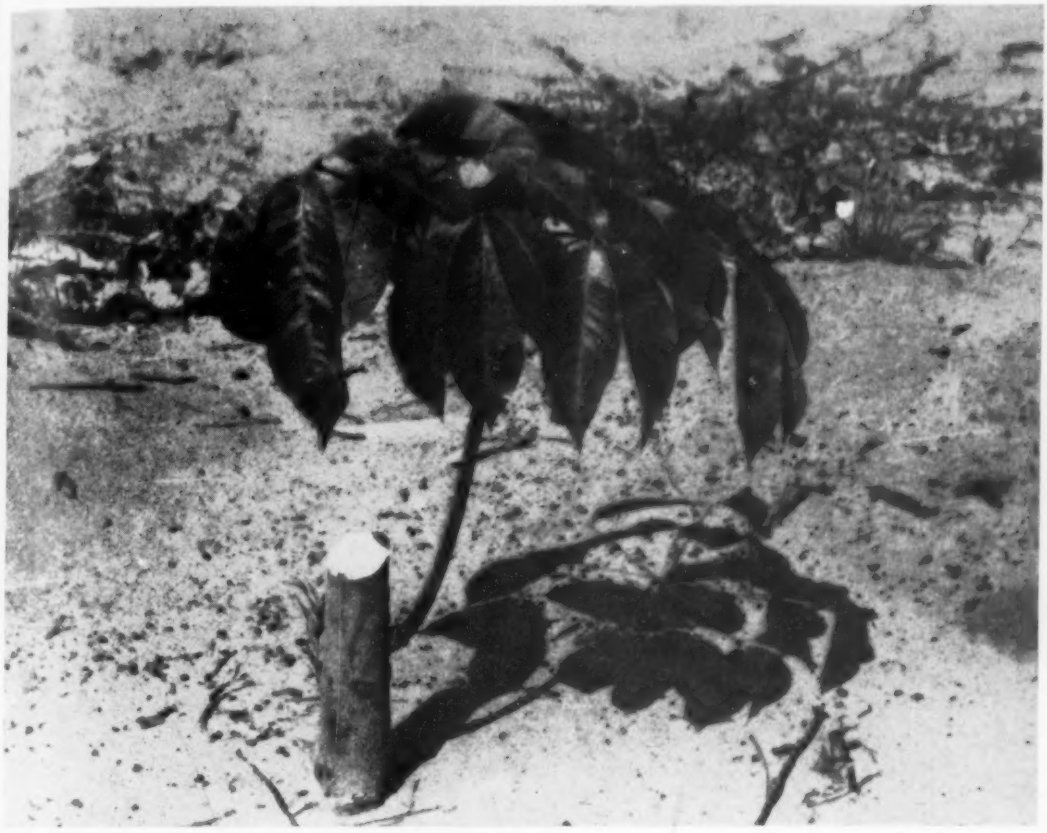
ONE END OF THE BOX IS TORN AWAY IN ORDER TO EXPOSE THE SPROUTED SEED AND THE ROOT SYSTEM.

to 100 trees is about all a *seringueiro* can take care of in one day. He makes several large, deep cuts into each tree by striking it with a large knife and then places a small cup under each cut in order to collect the latex which flows a drop at a time for several hours. After all his trees have been tapped in this manner he covers the same territory again, this time collecting the latex in a pail or other suitable container. The quantity of latex which he has obtained from all the trees of his *estrada* will probably not be more than one-half gallon, which will yield roughly only a pound and one-half of dry rubber.

All this tapping and collecting is done in the morning hours, and the afternoon is devoted to processing the latex into rubber. The oldest and still most common method used today in the Amazon Valley for separating the rubber from the latex is coagulation by means of smoke. The latex is poured over the end of a stick or paddle and is then held over a smoky fire which causes the latex to coagulate into a film of rubber. Then more latex is similarly added and this too is coagulated in the same manner. The process is continued until all the latex has been coagulated. The latex collected on subsequent days is also added until a large ball is formed. This large ball of wet rubber, which may weigh 100 pounds or more, is then removed from the paddle or stick and sold to a rubber buyer.

On the plantations of the Far East the processes of obtaining rubber from the trees are much easier. Instead of tramping through miles of thick jungle covering many acres of land in order to reach but a few trees, the tapper covers from 2 to 4 acres per day. Instead of tapping but 50 to 100 trees, he can easily take care of from 300 to 600 trees. He makes only one cut per tree by means of a special knife which he has been trained to use in a manner that will not damage the tree by cutting into the wood. In addition this type of cut yields more latex, and since it heals and the bark is renewed in a few years the same portion of the tree may be tapped again. The old system of tapping raises large growths on the tree and often kills it. The latex obtained on plantations is first strained in order to remove bark, sand, and other foreign material and is then placed in coagulating tanks where acetic or formic acid is added. On the following day the coagulum of rubber, which the acid has separated from the latex in a sponge-like slab, is passed between wringer-rolls and marking-rolls in order to squeeze out most of the water and to make the rubber into ribbed sheet form. The sheets are then placed inside a smokehouse for from 4 to 7 days, where they are dried and preserved by the smoke. These smoked sheets of rubber are much cleaner and drier than the rubber produced in form of balls by the old Brazilian method, and naturally demand a higher price. Much less work is involved in processing the rubber by plantation methods, and the production per man is much greater. Also on the newer plantations only improved and selected trees giving high yield of latex are planted.

It is quite possible that if the planting of rubber trees in Brazil is conducted in a scientific manner trees as good as or even better than those of the Far East may be produced. Brazil has the great advantage of a wider selection of starting material, which should permit development of a tree superior to any now known. In 1876 Sir Henry Wickham made his collection of *Hevea brasiliensis* seed from only one small area of the rubber producing region of the Amazon Valley and thus



A YOUNG RUBBER TREE SHORTLY AFTER BUDDING

THE BUD, WHICH WAS TAKEN FROM A HIGH-YIELDING RUBBER TREE, WILL FORM A NEW HIGH-YIELDING TRUNK.

did not secure material representing all the variations of that tree. In fact it is generally recognized that other regions of Brazil produce better strains. There is also a possibility that other Brazilian species of trees might produce even better quality rubber than Hevea.

There are in the Amazon Valley several species of Hevea other than *Hevea brasiliensis* and many other trees and shrubs which yield a latex of one form or another. Most of these latexes produce a rubber-like material, varying greatly both in quality and quantity. Some of these trees and shrubs give up their latex more readily than do the others. Some of these latexes coagulate very easily, others with more difficulty. Some trees require many years after planting, while others only a short time, before they can be tapped commercially. Some trees grow easily, without requiring much care, while others are quite delicate. Some are more susceptible to diseases than others. In fact there are often great variations between different strains of the same species. Therefore it can be seen that what is needed is a thorough study of and comparison between the various rubber-producing plants, including a study of their susceptibility to diseases and how to control these diseases, a study to improve the yields of latexes and rubber, and a study to determine the different physical and chemical properties of the various kinds of rubber. The result of all these studies may prove that the solution is to produce various types of trees which yield rubbers having different characteristics.

Variations in the yield of latex among different trees from seed of the same tree may be very great, as much as tenfold and more. Studies were made on Hevea trees in the Far East, and budwood for grafting on the

poorer trees was selected from those which were known to produce a good yield of latex. By continuous budding and selection over a period of years, trees have been developed which produce much more latex than the average wild tree does.

Several plantations were started in tropical America at the beginning of the century, particularly in the British and Dutch Guianas and in Trinidad. These plantations were started on a rather large scale without any previous research or experimental work and ended in ruin owing to attacks upon the tree by a leaf-disease known as the South American leaf-blight, caused by the fungus *Dothidella ulei*. This blight had been known to exist on the rubber trees of the South American jungle, but separation of the wild rubber trees from one another by other types of trees and the heavy undergrowth of the jungle has limited spread of the fungus. However, when the trees are planted closer together, as in plantations, this disease reaches greater severity and the leaves of the attacked plants wilt and fall. Repeated defoliations from the blight cause the tree to decrease its yield in latex and finally to die. The trees are not "born" with the leaf-blight but acquire it through contact with the fungus, which is spread from infected trees by winds. The rubber trees of the Far East have not been affected by this blight since the disease has never appeared there. However, it is generally believed that if the blight once got started there, it would prove to be a pest and might even exterminate the present trees from that part of the world.

In order to prepare for the possible estab-

THE AUTHOR EXAMINING A RUBBER TREE

THIS TREE HAS BEEN TAPPED BY THE MODERN FULL-SPIRAL METHOD IN WHICH ABOUT A MILLIMETER OF BARK IS REMOVED AT EACH TAPPING. THE WHITE LATEX IN THE GROOVE RUNS DROPWISE INTO THE RECEIVING CUP.

lishment of rubber plantings in Brazil, a research institution was set up in 1941 at the mouth of the Amazon River near the city of Belém do Pará, and called the Instituto Agronômico do Norte (Agricultural Institute of the North). The object of this institution is to study all agricultural products of the Amazon Valley, rubber being one of the most important. It will therefore conduct research on botanical, pathological, entomological, physiological, technological, and economic problems connected with rubber. It also plans to establish an agricultural school in which will be taught subjects pertaining to agricultural science, with particular emphasis on those subjects important to the Amazon Valley. Its location at the mouth of the Amazon is ideal for a research center on natural rubber since it is surrounded by many different types of wild rubber trees, and since Belém do Pará is the port through which passes all the rubber produced in the Amazon Valley. In fact, the name Pará-rubber was derived from the name of this city.

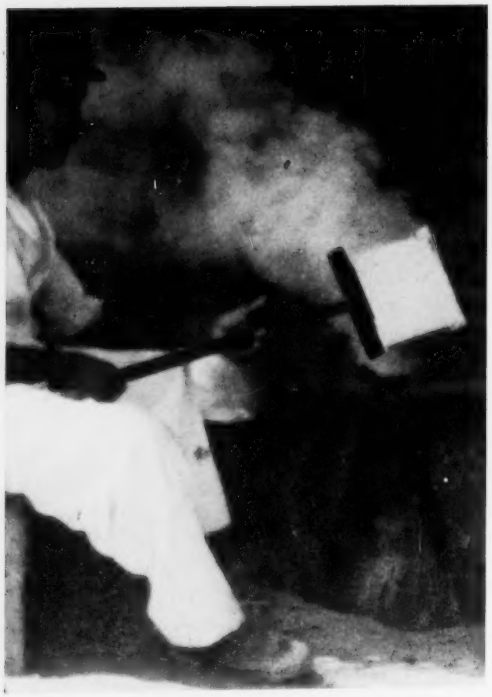
The Instituto Agronômico do Norte, or I.A.N., began with 10,000 acres of land completely covered with dense jungle. At the present writing about 500 acres have been cleared. A campus of about 50 acres is the site for more than 50 buildings, which include those for administration, general chemistry, botany and pathology, rubber technology, school of technology, warehouses, shops, nurseries, hothouses, homes, etc. More than 100 acres of the cleared land are planted with rubber trees which are under scientific observation and experiment.

Since, as has already been mentioned, there are many different types and grades of rubber produced by the various species of trees in Brazil, one of the most important researches is the study of the physical and chemical properties of these various rubbers. Such a study requires a laboratory equipped with the type of apparatus and machinery employed in the research, testing, and development laboratories of the larger rubber manufacturing companies of the United States. This was realized by Dr. Felisberto C. De Camargo, who, immediately upon becoming director of the I.A.N., began making plans for such a laboratory. Since scientific

A TYPICAL SERINGUEIRO

THE CONTAINER, WHICH IS USED FOR COLLECTING THE LATEX, IS MADE BY HOLLOWING OUT A NATIVE FRUIT.

workers with the requisite training in rubber technology were not available in Brazil, it was considered desirable to seek the assistance of the United States, which was greatly interested in obtaining natural rubber from sources in its own hemisphere. Consequently, by means of negotiations between the governments of the two countries, an agreement was reached that temporary technical assistance would be furnished by the United States. This resulted in the loan of the author of this paper to the I.A.N from the Rubber Section of the National Bureau of Standards in Washington, D. C., and also of Mr. Fredrick L. Downs from the Rubber Laboratory of the American Steel and Wire Company in Worcester, Massachusetts. It was the duty of these two rubber technologists to select and purchase for the Brazilian Government all the equipment necessary for the Rubber Laboratory, to install it in a new building especially designed for the purpose,



COAGULATING RUBBER FROM LATEX
A SERINGUEIRO USES THE PÁ-AGRONÔMICO METHOD.

and to instruct and train a staff of Brazilian scientists and technicians so that they could take over the operation of the laboratory after the services of the North Americans had terminated. All the apparatus and machinery for the laboratory were purchased in the United States and, with the cooperation of the Rubber Development Corporation, shipped by boat to Belém. Practically all this transportation took place at various times during the year 1943 when ship-sinkings were very heavy due to enemy action, but fortunately not one single item was lost. In about June of 1944 the laboratory was completed, research was started, and analyses and tests of wild rubbers began to be reported.

The physical and chemical tests on the wild rubbers, although quite routine in themselves, not only define the properties of individual samples of rubber but also give data valuable for other purposes. From all these data which are being prepared at the I.A.N., together with similar data being obtained at the Rubber Section of the National Bureau of Standards, a method is being worked out by which all crude wild rubbers may better be evaluated and graded.

Not only is the laboratory suited for this routine testing but it is well-equipped for conducting research work on rubber. Its location near the rubber trees puts it in a position to do many types of experiments which cannot be performed in other laboratories. As an example, a rubber technician can actually go out into the "back yard" of his laboratory, tap a rubber tree, bring in the latex, and conduct experiments on the fresh unadulterated product of the tree. The latex from most rubber trees will putrify and coagulate in the course of a few hours unless some preservative has been added, which in many cases alters the results of the experiments. It is a great advantage to any laboratory when it has an unlimited quantity of pure, fresh, raw material with which to work.

The Rubber Laboratory of the I.A.N., in its short existence, has already performed several valuable experiments. It has perfected a method for the coagulation of the rubber from the latex of *Hancornia speciosa*, known in Brazil as the *mangabeira*. Many trees of this species are distributed in various parts of Brazil, but very few of them are tapped, partly because of the difficulty of coagulating the latex and partly because of the poor quality of the rubber. It is difficult to get a good coagulation of the *mangabeira* rubber from the latex by the usual smoking method. The coagulating agents usually used for the Hevea rubber, acetic or formic acids, do not function unless used in such high concentrations that the process is made impractical. The method which in the past has generally been used by the natives of Brazil to coagulate the *mangabeira* rubber is to add a solution of ordinary alum. This seemingly gives a nice coagulation, but leaves the resulting rubber with very poor aging qualities. A few months after production the rubber becomes very sticky and tacky, a property not very popular with manufacturers of rubber goods. The Rubber Laboratory has improved coagulation by adding to the latex, in place of alum, another latex from *Ficus anthelminthica*, called in Brazil the *caxinguba*. It was also discovered that very small quantities of ordinary hydro-

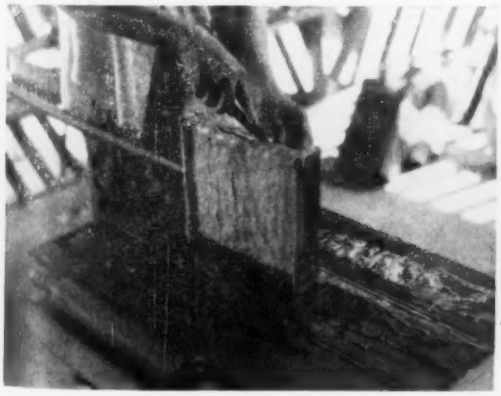
chloric acid form a satisfactory coagulum. Aging tests performed at the laboratory on rubber coagulated by various agents have shown that it is not the *mangabeira* rubber itself that naturally deteriorates rapidly, but that its poor aging qualities have been caused by the alum which had been used to coagulate it. Both accelerated aging tests and natural aging tests have shown that when *caxinguba* latex or hydrochloric acid are used as coagulants, the resulting *mangabeira* rubber is much superior to that which has been coagulated by alum.

The routine testing at the laboratory has shown that in some instances the practical rubber graders, who from necessity have been taught to make their tests on the rubber in the unvulcanized state without the aid of scientific equipment, do not always evaluate samples of rubber in the same order as do the scientific tests which are made both on the unvulcanized sample and the vulcanized product. Several types of rubber have been considered by the rubber graders as weak or unclassified, when the scientific tests have actually shown them to be of excellent quality, equivalent to the best grades of plantation rubber from the Far East. Thus in the grading of rubber alone, this laboratory located near the source of supply of rubber can be considered an asset to the rubber producers, to the manufacturers, and also to the consumers.

The Rubber Laboratory operates a small sheet-rubber factory located a few miles out in the jungle, where the rubber trees are more abundant. This factory is equipped to coagulate or process rubber by any of the various known methods. It processes an average of more than 100 liters of latex each day, and thus makes a very useful "pilot plant" for the laboratory to verify its experimental conclusions.

This rubber factory has studied various systems of coagulating and processing Hevea rubber and has developed a method which it recommends for use by the natives of the Amazon valley. It has been named the *Pá-Agronômico* method. *Pá* is the word for paddle in the Portuguese language. The term "*Agronômico*" is taken from the name of the institution, the I.A.N. This system of processing employs the old method of smoking the latex over a smoky fire but uses a specially designed wide paddle around which a band of rubber is coagulated. After from one to two liters of latex have been processed in this manner, the rubber is cut along one edge, peeled off in sheet form, run between rolls for better sheeting and marking, and then dried either in the shade, in a heated room, or in a smoke-house.

The processing of rubber from latex by the *Pá-Agronômico* method is a very slow process and is not recommended for use on plantations where large quantities of latex are obtained or on other establishments where trained help and coagulating acids or chemicals are available. But for the uneducated native or small-producer in the Amazon jungle, who generally has no knowledge of mixing acids or calculating their strengths,



STEPS IN THE PÁ–AGRONÔMICO METHOD

Left, CUTTING THE RUBBER ALONG ONE EDGE OF THE PADDLE; *right*, STRIPPING IT FROM THE PÁ-AGRONÔMICO.

the method has considerable advantage. It produces rubber in sheet form, which is more easily examined for dirt and other foreign matter than the ball rubber. The rubber sheets are dry and ready to go directly to the manufacturer, whereas the ball-rubber requires subsequent washing and drying. The best grades of *Pá-Agronômico* rubber in Brazil have been selling for the same price as the best smoked sheet.

Natives of the Amazon Valley having more than average ability and personality are sought by the I.A.N. to work in the rubber factory and are given a thorough training-course in the processing of rubber by the improved methods, including the tapping and care of the rubber trees. After they have become proficient they are sent to various substations of the I.A.N. or to other regions of the Amazon Valley where they may instruct their fellow-countrymen in the improved rubber-producing methods. The system of transferring information from one native to another is likely to be more successful than to send scientists into the field, since the natives usually resent being told by botanists, agronomists, chemists, and other "foreigners" how they should tap a tree and process the rubber. The native usually takes the attitude: "My father was a *seringueiro*. So was my grandfather. What right have you to tell me anything about my work?" The system of instruction adopted by the I.A.N. seems to be proving its worth. Sheets of *Pá-Agronômico* rubber are beginning to appear from different corners of the Amazon, but considerable time will still be necessary to cover such a vast region. As the cultivation of rubber becomes more general in the valley and the quantity of latex becomes too great to be handled by the older processing methods, the natives will be taught to use more efficient methods.

SQUEEZING WATER FROM THE RUBBER
THE COAGULUM IS ROLLED BY HAND BEFORE IT GOES THROUGH THE WRINGER CALLED SHEETING-ROLLS.

In the field of synthetic rubber, which has developed so rapidly in the United States within the last few years, the manufacturers have found that some types of synthetic rubber behave better than others for specific purposes. There is no single type which is better than all others for all purposes. Undoubtedly the same is true for the various types of natural rubber. In fact, before the war when all types of natural rubber were available, one well-known company which manufactures electrical cables always used *Up-River fine Pará*, a type of rubber produced in the upper Amazon Valley. The company claims that for this particular purpose the *Up-River fine Pará* is superior to any other rubber, including the best grade of plantation rubber of the Far East. Another well-known company which manufactures adhesives always insisted on using a rubber of different type from another section of Brazil. Thus it seems that with the many varieties of rubber that are at the present time produced from the different species of trees in Brazil, and with the unlimited number of new strains of trees that can be developed in the future, rubber products of a quality superior to that which we have known can be manufactured.

Brazil may have new species of rubber trees in the future which may prove to be more popular than *Hevea brasiliensis*. However, up to the present time the rubber from this tree has been studied more than any

other of the natural rubbers, its characteristics are better known, and it will undoubtedly play the most important role in natural rubber for at least a number of years. Thus, for the present at least, Brazil plans to plant *Hevea brasiliensis*.

The Ford Company began its plantation of *Hevea brasiliensis* in the valley of the Tapajós River in Brazil, and considerable loss was taken due to the south American leaf-disease. The company had grafted its Hevea seedlings with buds from clones obtained from various parts of the world and known to come from trees producing a high yield of latex. A very large percentage of these trees contracted the blight and threatened to die unless something was done. The Ford Company strained every effort to save its great investment. It began a series of various experiments to try to produce a tree resistant to the disease.

The greatest success came from crown-budding the high-yielding trees of the plantation with clones having high resistance to the disease. The Companhia Ford Industrial do Brasil (The Ford Rubber Plantation), the I.A.N. at Belém, and the U. S. Department of Agriculture have been working in cooperation both at Ford's plantation and at the I.A.N. on this method of producing a superior strain of the *Hevea brasiliensis*. The method involves the planting of a tree from seed which is known to give a strong and healthy root-system. After the tree is about one year old it is bud-grafted a few inches from the ground with the bud of a tree giving a high yield of latex. The old tree is cut off just above the newly-grafted bud, and the bud then grows and becomes the new tree. The result is a two-component tree, consisting of a root-system of the first and a stem and crown from the second. Since this crown is usually very susceptible to the leaf-disease, it must be sprayed with a fungicide at frequent intervals in order to keep the tree in good condition. The spraying method for control of the blight is effective and practical only when used in nurseries where the trees are small and close together. After this budded tree has grown for about a year and has attained a height of from 10 to 12 feet, it is top-budded (or crown-budded) about 6 to 7 feet from the ground with a clone known

SHEETING THE RUBBER

to have resistance to the blight. After this bud has "taken," the old crown is completely removed just above the newly-grafted bud. This procedure produces a three-component tree, built up from three different strains. After this new type of tree was developed, the question became, "What effect will the new crown have on the yield of latex from the tree?" Fortunately the answer was in the direction that the experimenters had hoped. The yield of latex, which is taken from the trunk of the tree, remained high, and the new crown maintained its resistance to the leaf-blight.

In all these first experiments on the double-budding system of producing a new tree, only strains of *Hevea brasiliensis* were used. The double-budding was naturally not expected to have any effect on the quality of the rubber since the tree was still purely of the one and same species. Since an extremely small percentage of *Hevea brasiliensis* trees are resistant to the leaf-disease, it would be convenient to top-bud with other resistant species also, such as with *Hevea benthamiana* or *Hevea spruciana*. These latter trees, however, are generally considered by rubber graders to produce a rubber which they classify as weak and inferior. For experimental purposes the Ford Company made a number of such buddings several years ago, and the trees have recently reached the tapping stage. Samples of rubber produced from these trees, together with samples produced from similar trees top-budded with

RUBBER FACTORY OF THE INSTITUTO AGRONÔMICO DO NORTE
IN THE MIDST OF THE JUNGLE, EXPERIMENTS ARE CONDUCTED ON THE PROCESSING OF LATEX INTO RUBBER.

resistant strains of *Hevea brasiliensis*, were tested in the Rubber Laboratory of the I.A.N. and it was found that the good qualities of the *Hevea brasiliensis* rubber were not lost by crowning the trees with the other species.

It is the belief at the I.A.N. that Brazil can now begin the cultivation of rubber and depend on the double-budding system to produce a good, strong, disease-resistant tree giving a good yield of latex and a rubber of good quality. This system is more costly than the single-budding method used in the Orient and other disease-free areas and will require about an extra year before the trees get into production. However, the plantings of Brazil will then consist entirely of trees budded for high yield. In this respect they would be superior to most of the present ones of the Far East, where only a rather small percentage of the rubber trees are of high-yielding types. The restriction scheme which has been practiced in the Far East over a number of years has prevented the rubber-growers from making large conversions to the higher-yielding clones.

In the Far East there are rubber plantations of all sizes, some consisting of thousands of acres. In addition there are thousands of families who have but a few acres of land each, part of which is planted in rubber trees, the rest being used to grow food-crops. It has been noticed that this latter type of rubber-grower can sell rubber at a lower price than the large plantations and can keep his rubber moving on to the market during periods of overproduction and low prices. Because of this stability the I.A.N. is recommending small one-family units for Brazil instead of large plantations. For ease of development it is planned to place a large number of these small units in the same locality.

The I.A.N. has for several years been producing budwood and budded stumps in its nurseries for future plantings. It now has sufficient quantity on hand to begin planting on a rather large scale in three widely differ-

ent localities. The object of planting in different regions is to try to spread rubber planting enthusiasm to different parts of the Valley and to determine the effects of different climates and soils on the trees. In this plan the Brazilian government will finance the planting of these regions. It will then assign the planted land to natives who show good intentions to continue the cultivation, each land-holder receiving about five acres on which are planted 400 or more rubber trees. Some of the land to be given him will be left free from trees and is intended for the farmer to grow food-crops sufficient for his family. He will be dependent to a large extent on the food-crops for support until the trees begin yielding rubber, which usually requires about 6 years. Until the rubber trees come into full bearing the government will give him a small salary and in addition a certain number of points for time served in cultivating the trees. After a given number of points have been accumulated, the land will be turned over to him. If he gives up his work before this time, he will lose his points and the opportunity to grow rubber.

Under this system a rubber-grower should collect and process about 2 tons or more of rubber per year from his few acres. At fifteen cents a pound for his rubber this would give him a minimum annual gross income of $600.00. This may seem to be a very small income to us, but it is actually very great as compared to what he has been receiving when producing in the neighborhood of one-tenth that quantity of rubber from the wild trees of the jungle. The work with the rubber would not occupy all of his time, so he would have ample opportunity to work in his vegetable and fruit gardens, to raise hogs, chickens, etc., and to fish. His necessary expenses would be small and consequently he could live on a much higher scale than he ever has in the past.

It is difficult to predict what the price of rubber will be after the world again returns to normal conditions. For several years previous to the war, natural rubber sold for about 20 cents per pound. At this price many rubber-growers of the Far East made large profits, and on a competitive market they can and probably will reduce the price of rubber considerably. The manufacturers of synthetic rubber are predicting that their production costs will be as low as 15 cents per pound after the war. If this prediction is correct, natural rubber may sell for approximately the same price. Consequently the quotation of 15 cents per pound for the natural rubber used in the calculation for the income of the Brazilian native rubber-grower seems reasonable.

Before this rubber program comes into its own, there are many obstacles which must be overcome. The first and most important is the unsatisfactory condition of health and sanitation in the Valley. Insect life thrives extremely well in such a climate, and unless steps are taken to improve sanitation and to eliminate the malaria-carrying mosquito and other harmful organisms, it will be difficult to induce outsiders to come into the Valley. The available manpower must be greatly increased in order to take care of the large rubber production program. Schools should be established to teach plantation methods, rubber technology, etc., to the natives of North Brazil. Industries operated by trained native technicians should be relatively stable. Imported technicians who are not accustomed to the tropics are less likely to remain indefinitely in the rubber-growing areas.

In conclusion, then, it might be stated that with a good system of rubber research and technical schools established in the Amazon Valley, Brazil should be able to restore rubber production as a farming enterprise and compete favorably in quality and price with both the natural rubber of the Far Eastern producers and with the synthetic rubber of the United States manufacturers.

SCIENCE AND PREJUDICE*

By GENE WELTFISH
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In a sense, the title of this paper is anomalous. For science, being an instrumentality or tool, is neither prejudiced nor unprejudiced. It is therefore rather to the scientist that my remarks are directed.

The popular conception of science is that it is in the main disinterested. This commonly implies that since the scientist practices his techniques not in his own interest, but in the interest of somebody or something else, he can be free of emotional involvement in the outcome and is therefore unprejudiced. The history of science, however, is replete with instances that belie this supposition.

One of the difficulties with this popular notion is that it is derived from considering science as a species of gospel or revelation, divorced from the scientist. The fact that the scientist is a mere human being and that his science is merely an instrument for seeking the truth is little understood.

Much is to be said for the devotion of the scientist in perfecting his methods and techniques. On the whole, he does a good job in accordance with whatever facilities may be available at any given time; and whatever differences of opinion scientists may have on technical matters, their standards of objectivity in this field are very high. But this preoccupation often overshadows the scientist's consideration of the purposes for which his investigation is being carried out, and he often neglects to apply to the formulation of purposes and uses the same dispassionate standards that he applies to his technical methods. It is in this respect that science today is challenged.

In order to make the case concrete, I shall relate a story from the history of anthropology. During the war of 1870 a bombshell landed on the roof of the Natural History Museum in Paris. The director, the eminent anthropologist, de Quatrefages, was moved to remark that the Germans were congenital barbarians and had no appreciation of culture. He further implemented his remarks by writing a pamphlet called "The Prussian Race" (*La Race prussienne*, 1871), in which he stated that the Germans were not Teutonic at all, but were descended from the Finns, who were to be classed with the Lapps—all alien Mongolian intruders into Europe. A more muddy, irresponsible, and unscientific statement would be hard to find.

The German anthropologist, Virchow, replied by instituting an extensive government census of the color of the hair and eyes of six million German school children. In the process, many new refinements were developed for describing these physical features. But how this demonstrated their lack of descent from the Finns, and in turn from the Lapps, and in turn from the Mongols, no one troubled to ask. As long as the technical measurements were all right, all was well. It was also altogether too much to expect that someone would ask the question: If Germans are descended from Finns, Lapps, and Mongols, does *that* make them barbarians today? Are not all of us ultimately descended from barbarians?

In the meantime a rumor began to circulate among the peasant population in Posen that all Catholic children with black hair and blue eyes were to be sent out of the country, some said to Russia; others said that the king of Prussia had been playing cards with the sultan of Turkey, and had staked and lost 40,000 fair-haired, blue-eyed children; and there were Moors traveling about in covered carts to collect them; furthermore, the schoolmasters were helping them, for they were to get five dollars a head for every child they handed over. One can hardly feel that Virchow's reason for his investigation was much more valid than this.

As a result of the rumor parents kept their children away from school and hid them, and in the streets of the market town the children would cling to their parents in terror. The

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affair ended when a local school teacher told the parents that it was only children with blue hair and green eyes that were wanted.

In his *History of Anthropology*, in which this case is described, A. C. Haddon remarks that the results were of great service to the Science of Anthropometry.

In spite of its general comic aspect, this story has a number of serious implications. It reflects some basic attitudes of the scientist that carry over into the present day. Although Virchow and de Quatrefages were among the world's most eminent scientists, they did not hesitate to use their elaborate scientific techniques to implement a spiteful personal animosity, and to make assertions that were incapable of proof. Moreover, Virchow, in setting up a census involving six million children, felt no need to explain his purpose to their parents, even though they felt sufficient anxiety to invent a weird reason for his action. There was also a whole corps of scientific workers who likewise found it unnecessary to inform the public what the investigation was about, and there was also the school teacher who tried to allay the parents' fears by a fantastic description of the children that were reported to be wanted.

And, finally, the British anthropologist, Haddon, writing in the year of Hitler's rise to power, evaluates the incident by the effects it had upon the development of measuring techniques, without saying anything about the falsity of the initial premises and of what it added to the doctrine of racism. This is a typical attitude even today and reflects considerable discredit on the fundamental morality of the scientist.

Now let us transport ourselves through time to this war and to our own era. It was in Germany, in 1942, that Scientist X was given a problem to work on. He was to perfect a method of human extermination that would render the bodies easily disposable and the whole affair was to be quick and efficient. Scientist X went to work with admirable method and efficiency and produced a gas whose effects would be best achieved if the exterminees took a shower beforehand. Scientist Y planned an efficient incinerator, etc. He need have no qualms as the exterminees were, of course, worthless human civilians, mainly Jews and agitators; or perhaps he didn't ask—simply went to work with his customary scientific accuracy; his scientific integrity was beyond reproach; he neither made blunders nor sabotaged his technique.

It is not hard to see how the attitudes in incident A can shade into incident B. Would it ever be possible for a Nazi regime to flourish if scientists did not take orders and cooperate? There is no doubt that many of the scientists acted under duress—just as the Russian and Czech prisoners were forced to enter into actual combat along with the regular German army. However, there should be a dishonor roll of scientists who collaborated willingly, such as Alexis Carrel, who last autumn was apprehended by the French people.

I am certainly not trying to imply that scientists are to blame for this war. I am only trying to demonstrate that scientists, like the rest of our contemporary population, are sadly lacking in the fundamental values that would have made such a war as this im-

THE SCIENTIST'S OATH

I pledge that I will use my knowledge for the good of humanity and against the destructive forces of the world and the ruthless intent of men; and that I will work together with my fellow scientists of whatever nation, creed, or color, for these, our common ends.

possible. But unlike the rest of the people, the scientist can escape responsibility for his lack of values by the all-too-familiar ascent into the ivory tower—which is simply another way of saying that he can escape into the intricacies of his techniques and methods.

Some years ago, while attending commencement exercises, I heard the medical graduates recite the Hippocratic Oath. I was impressed by its solemnity and also by the fact that this was the only group of graduates that was asked to express any public responsibility in the exercise of its future profession. We well know that not all physicians are strictly faithful to the implied ideals of the code. But it is also a fact that such practices, when exposed, are subject to considerable public censure.

The scientist, on the other hand, does not have the same kind of check upon his actions. On the contrary, his freedom from public responsibility is condoned and considered to be his right. This, despite the fact that science has far-reaching social consequences—considerably greater than the actions of the individual physician.

In the face of many facts, I maintain that the disinterestedness of the scientist is largely mythical—that it amounts to a lack of evaluation of purposes, and that as a consequence, the scientist can readily become the creator of havoc and destruction. I further maintain that such a robot scientist is a greater menace to humanity than the robot bomb. In our reconstructed world graduating scientists should take cognizance of their responsibilities for the social consequences resulting from their use of scientific techniques. To make them conscious of their obligations I propose that each new group of graduates take a solemn oath, for example:

I pledge that I will use my knowledge for the good of humanity and against the destructive forces of the world and the ruthless intent of men; and that I will work together with my fellow scientists of whatever country, creed, or color, for these, our common ends.

DR. GENE WELTFISH

GENE WELTFISH, Ph.D., is probably most widely known as coauthor with Professor Ruth Benedict of a pamphlet entitled *Races of Mankind*, which was published in 1943 by the Public Affairs Committee to combat race prejudice. Since 1936 Miss Weltfish has been an instructor in the Department of Anthropology of Columbia University. Our heroine has been a New Yorker since her birth in 1902. She was educated at Barnard College and took her doctorate in anthropology at Columbia. An atypical New Yorker, she knew that the Indians do not live in Indiana; from 1928 to 1935 she lived among a number of American Indian Tribes in Oklahoma, New Mexico, Arizona, Louisiana, and North Dakota; investigated their arts, manufactures, poetry, language, social and economic life; and made a number of collections for the American Museum of Natural History and the Reading Public Museum in Pennsylvania. She arranged materials for exhibit in several museums. Her activities of recent years are explained by her social conscience. She writes: "About six years ago I became convinced by the course of world events that the scientist was unjustified in maintaining an 'ivory tower' isolation and since that time I have been working on the race problem and the popularization of anthropological material in the schools and other fields. I think the scientist should do something about society *before* the buzz-bombs fall on his laboratory." So we find Dr. Weltfish lecturing in the East and Middle West for churches, schools, and community organizations; serving on the editorial board of the *Journal of Social Issues*, on the executive committee of the A.A.Sc.W., as Executive Secretary of the One World Citizens League, and as Honorary Chairman of the Citizens Committee of the Upper West Side. We hope that our readers will take her Scientist's Oath to heart and "give the little lady a hand."

SCIENCE AND DIETARY WISDOM

By SAMUEL BRODY

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The destiny of a people depends on the nature of its diet.—A. BRILLAT-SAVARIN.

THE haunting, seductive radio voices on behalf of various food products, vitamins, and laxatives sensitize scientists as well as laymen to the problem of dietary selection. Food rationing, educational efforts of various agencies in behalf of the "basic seven" foods, victory gardens, and related dietary problems add to the general food consciousness. Sociologists, nutritionists, public health workers, and physicians are brooding over the Stiebeling, Kruse, and related surveys, which indicate by comparison with nutritional standards that most of our citizenry is ill-nourished. While only 10 to 15 percent show clinical symptoms, 50 to 70 percent are said to have subclinical nutritional disorders, to suffer from decaying teeth, bleeding gums, digestive disturbances, sore tongue, fissured mucous membranes, and various nervous and psychic manifestations such as vague aches and pains, fatigue, insomnia, and apprehensive fears. Conclusions from these surveys are substantiated by Selective Service reports indicating that 30 to 40 percent of our men in the prime of life are unfit for military training. It is said that the majority of those disqualified have preventable nutritional defects. Soil-nutritionists contribute to this somber picture by suggesting a parallel between the deterioration of beast and man in our present dust-bowls and the decline of past civilizations owing to soil depletion. Then, too, there is a growing humanitarian concern about the world food scarcity which this country is asked to relieve because "the world cannot long exist in peace if half of its people are well-fed and the rest ill-fed" (Mattill).

The writer is particularly interested in the effects of growing science and technology on human wisdom. Some of the general aspects of such effects have been discussed in the September 1944 issue of this magazine. The present essay extends this general discussion to a particular problem—the relation of rapidly growing science and technology to dietary choice advantageous to long-range survival. Such selection of food leading to optimal health and longevity of individual and species is here called *dietary wisdom.*

IT IS generally known that dietary selection in modern man is not always motivated by biologic wisdom or homeostatic mechanisms as it is in subhuman species or in primitive man; instead biologically irrelevant traditions, fashions, prejudices, prestige symbolisms, and advertising often govern choice of food. Curiously enough, some of the most nutritious foods have the lowest prestige values. For instance, the most nutritious parts of grain are the germ, middling, and bran, which are generally removed in milling and "shunted into the mouths of chickens, cattle, and hogs" (Carlson). The most nutritious parts of the animal carcass are often the visceral organs, many of which are discarded as offal. Much of the skim milk is fed to chickens and hogs and even dumped into sewers, although it is the most nutritious part of milk as it contains all the milk proteins, minerals, water-soluble vitamins, the uniquely important milk sugar, and half of the original milk energy. The failure to utilize all the skim milk and whey for human consumption results in unbelievably large food losses, said to be enough to supply the protein needs of perhaps 35 million persons, riboflavin needs of 65 million, and calcium needs of 80 million (Krauss); the protein loss in skim milk is said to be equivalent to that in 20 million beef steers (Rose).

Yellow corn is nutritionally superior to white corn, but the poor Southern whites prefer the white varieties because yellow corn is "nigger food." Sharecroppers near river banks avoid eating river fish because "fish is eaten only by them river rats" (Bennett), referring to the "river people" whom the sharecroppers consider as social inferiors. The peanut is an excellent food, but it is said

not to be eaten by man where it is grown most luxuriantly because pigs eat it there; it is "pig feed." On the other hand, many canned and packaged foods are highly esteemed by the rural poor because of their high social prestige value; they are "city foods" and brightly packaged. White flour, starch, and sugar have high social prestige value also because they used to be expensive and, therefore, were consumed only by the rich. Their present popularity is due to such factors as traditional prestige, taste to which most consumers have been conditioned, superior keeping qualities, and preconceived notions concerning the inherent desirability of "sweetness," "purity," "whiteness," in food. A major reason for the popularity of these denatured foods is, perhaps, a merchandising one. Their sale and consumption are promoted because they are particularly suitable for large-scale manufacture, storage, and distribution.

For reasons of religious and related traditional symbolisms pork, shellfish, lobsters, and crabs are not *kosher* to orthodox Jews; for similar reasons, Moslems do not eat pork, Hindus do not eat beef, and Bantus do not eat fowl. White North Americans do not eat the meat of horses, dogs, cats, rats, alligators, snakes, sails, and insects, although some peoples eat such animals.

Fish eggs and fish in various forms—pickled, smoked, dried—are dietary staples in much of Europe and Asia, but relatively little is consumed in this country, although, on a dry basis, fish has approximately the same nutritional value as meat and is obtained by the fishing industry at a manpower cost of about a tenth that of meat. After the oil is removed, most of the commercial ocean catch in this country is used for animal feed and fertilizer.

These examples indicate that foods are often chosen not because of their nutritional value or availability but because of uniquely human conditioning to symbolisms or prejudices which do not complicate the lives of subhuman species and because of merchandising factors which make it more convenient or more profitable to market certain food products.

Dietary selection has become particularly confused by the extremely rapid development of technology of food processing. Our dietary-selective mechanisms were not evolved for wise discriminations between recently developed processed foods, especially when artificially flavored, colored, and promoted by high-pressure advertising. For these reasons the rapid development of science and technology does not necessarily improve the nutritional condition of the average consumer. Indeed, Dr. Russell Wilder, an eminent dietary authority in a famous clinic, expressed the belief that malnutrition is more serious now than it has been at any time in our history just because of the perfection of certain food technologies (as the manufacturing and wide consumption of patent flour, starch, sugar and sugar products). The science of nutrition has furnished powerful tools to the physician skilled in dietary therapeutics but it has aggravated the nutritional hazards of the average man. It has been said that God provides the remedy before creating a disease. This is true of the two-sided effect of rapidly-growing nutritional science.

IT MAY be recalled that nutrition, like reproduction, is not a new thing under the sun; that it existed before the appearance of a brain. Therefore, under natural conditions, dietary selection is a process that is largely automatic even in the highest organisms. For instance, there is no dietary choice during the period of most significant growth and development; namely, during the prenatal and infantile periods. During prenatal life the embryo and fetus must subsist on the nutrients provided by the egg or uterus; during the infantile period, the mammal must subsist on milk and the bird on "crop milk" or equivalent nutriment.

Following infancy, the strict carnivore normally subsists on a given animal species that it was evolved to consume. The herbivore has a wider range of choice, and it has instinctive preferences for nutritious and aversions to injurious plants. Herbivores also exhibit such discriminatory phenomena as search for salt licks to supplement the salts in which herbage is relatively poor. During pregnancy and lactation when there is increased need for minerals, especially for calcium and phosphate, or when there is

dietary deficiency in the mineral content of food plants owing to poor soil, herbivores automatically search for calcium- and phosphorus-rich bone, limestone, and earth. In search for these special nutrients, the animal may be confused and mistake poisonous lead-containing paint, for example, for lime-containing whitewash, just as man may be confused between the choice of artificially colored or flavored unwholesome food and a naturally colored and flavored wholesome food. Pregnant women, likewise, often develop special dietary cravings, but they are usually confused concerning their nutritional needs by the conditioning of their tastes to processed foods and related substances.

Omnivores have the widest feeding range and the greatest discriminatory powers in dietary selection. For instance, Richter observed that rats maintain their nutritional condition relatively normal despite experimental designs to upset normality. They maintain a normal sodium salt level despite great increase in salt loss following extirpation of the adrenal glands, provided that salt is furnished in a separate container; they maintain a normal calcium level despite great increase in calcium loss following the extirpation of the parathyroid glands, provided that calcium is furnished in a separate container. The loss of sodium salt or calcium salt is reflected by heightened hunger and appetite for the corresponding nutrient so that the surgically induced losses are compensated by extra nutrient intake. Indeed, Richter suggested that taste thresholds may serve as delicate indices of nutritional deficiencies and of disease of metabolism-regulating glands. Rats thus show excellent dietary wisdom in selecting the needed nutrients if given opportunity to do so by the cafeteria feeding style and if not confused by conditioned habits or by synthetic flavors or odors. It is emphasized that the force of strongly conditioned habit—in rat or man—is often greater than the force of inherited behavior patterns. Man is a product of environment as well as of heredity.

Another homeostatic mechanism compensating for some dietary deficiency is the hypertrophy of the gland regulating the metabolism of the given deficient nutrient. Critical iodine and calcium deficiency leads to hypertrophy, respectively, of the thyroid and parathyroid glands; excessive carbohydrate consumption leads to hypertrophy of the islets of Langerhans that produce extra insulin required for the extra carbohydrate metabolism. The glandular hypertrophy compensates in part for the dietary deficiency or excess.

What was said about endocrine influence on the adjustive choice of foods or nutrients often holds for vitamins and minerals. For instance, withholding thiamine from the diet shifts the rat's dietary preference from carbohydrates and proteins, the oxidation of which involves thiamine, to fat, the oxidation of which does not involve thiamine. When thiamine is added, the rat's preference is reversed to carbohydrate and protein.

Much of what was said about the rat's ability to choose foods wisely holds for other omnivores, including unconditioned pigs (Evvard), chicks (Funk), and children (Davis, Sweet). As regards herbivores, Dove reported that rabbits show excellent discrimination in choosing the most nutritious herbage, and Nevans observed that dairy cattle choose wisely of their natural herbage diet but that their judgment is blurred with respect to concentrates (processed) feeds for which their discriminatory mechanisms were not evolved.

One is tempted to cite in conclusion the remarkable dietary wisdom in the honeybee. Its social life is conducted on a caste system consisting of one queen and many worker bees. The large fertile queen is genetically identical with the worker bee; she attains her royal status by dietary means alone, by being fed "royal jelly"—a secretion produced by the nurse worker bees—in the larval stage, while the larvae of the future worker bees are not so fed. This is demonstrated by the fact that commercial queen raisers produce queens from any larva by simply feeding it royal jelly from hatching. In this connection one wonders how the better diets usually enjoyed by the children of the well-to-do differentiate them from underprivileged children not so well fed. R. F. Harrell (Teachers College, Columbia University) reported increased learning ability in orphanage children receiving a vitamin supplement.

The worker bee differs greatly from the queen bee, but perhaps relatively no more than the human cretin differs from the average normal human being—and it appears that both types of differences are produced by dietary chance. The congenital human cretin in iodine-deficient regions is apparently the product of a dietary chance circumstance—severe iodine and perhaps thyroxin deficiency in the mother during pregnancy. Other congenital abnormalities may likewise be due to dietary deficiencies in the mother during pregnancy. For instance, congenital blindness, missing kidneys, missing limbs, cleft palate, hare lip, and other abnormalities were apparently produced in calves (Moore), pigs (Hale; Zilva, Golding, Drummond, and Coward), and rats (Warkany) by withholding vitamin A (and also vitamin B_2 in rats) from the pregnant mother's diet. Richardson and Hogan observed about a dozen cases of hydrocephalus—characterized by a great skull with little brain—in new-born rats from mothers fed a "synthetic diet" complete in all the *known* dietary constituents. Deficiency of some *unknown* essential dietary factor may account for this abnormality because it was not observed on rations which contained *crude* vitamin carriers. May not some related disorders, such as some types of spastic paralysis, result from dietary deficiency during pregnancy? Faulty teeth structure is often attributed to deficiencies in dietary minerals and vitamins D and C in the pregnant and lactating mother. Sherman observed that under the given conditions white bread sufficed to nourish a first generation of rats but not successive generations. Similar cumulative nutritional deterioration may occur in human society.

Where is the dividing line between automatic and conscious dietary wisdom? The enlargement of the thyroids and parathyroids under conditions of iodine and calcium deficiency is clearly automatic. But how much conscious selection is there in the rat's greater intake of table salt following adrenalectomy or greater intake of calcium salt and less intake of phosphate salt following parathyroidectomy? Or how explain the rat's preference for fat and aversion to carbohydrate and protein on a diet deficient in vitamin B? Richter reported that cutting the rat's taste nerves abolishes his ability to make the beneficial dietary selections. The taste buds are the rat's essential "dietary wisdom" components. What are the corresponding dietary wisdom components in man, whose taste buds are often unreliable guides to food value because of conditioning by tradition and confusion by food processing and advertising? Should man adopt the science of nutrition rather than taste and symbolisms as the safer guide for dietary selection? If so, what is the status of the science of nutrition and how reliable is it as a nutritional guide?

THE founding of the science of nutrition is attributed to Lavoisier, who, together with Laplace, observed, about 165 years ago, that animal heat was derived from the oxidation of the body's fuels as candle heat is derived from the oxidation of candle fuel. He, therefore, concluded about 1777 that life—and nutrition is its basic process—is a chemical function: "*La vie est une fonction chimique.*"

It is true, as Lavoisier concluded, that the energy for maintaining the body machinery is derived from oxidation of body fuels. But there are uniquely biological factors in animal oxidation not encountered in a burning candle. For instance, the oxidation—the burning—of a candle is accomplished directly by raising the temperature of its wick end far above that compatible with life. The fires of life, on the other hand, glow at a very much lower temperature than that of a candle, and the oxidation is not directly by combination of the fuel with oxygen but stepwise by way of a long chain of intermediate biochemical reactions, each of which is controlled by one of an interrelated system of biocatalysts; that is, enzymes and hormones of various categories.

These reactions, unlike those in a candle, are reversible. For instance, the oxidation of body sugar—glucose—is not a simple combination of sugar with oxygen to form water and carbon dioxide as it occurs on burning sugar outside the body. First, much of the body sugar exists in starchlike glycogen. When the glucose in the blood declines below a certain level, the glycogen is depolymerized; not by simple hydrolysis, however, as starch is hydrolyzed *in vitro,* but by combi-

nation with phosphoric acid to form the Cori-ester, glucose-1-phosphate. The formation of this ester, like that of the many subsequent intermediate compounds, is under the influence of a specific enzyme—in this case under the influence of the enzyme phosphorylase—and this reaction is reversible. Many other intermediate compounds, including hexose diphosphate, triose phosphate, glycerophosphoric acid, phosphoglyceric acid, pyruvic acid, lactic acid, methyl glyoxal, glycuronic acid, glyceraldehyde, acetaldehyde, dihydroxyacetone, are similarly formed under the influence of specific enzymes during oxidation. Deficiency of a specific biocatalyst for the oxidation of the corresponding intermediate metabolic product may block the oxidation process at the given reaction stage with the accumulation of the given intermediate product and thus lead to dietary deficiency intoxications and disease, such as beriberi, pellagra, and alcoholism.

The biocatalysts, or enzymes, are composed of many components, including vitamins, such as thiamine, certain inorganic elements, such as iron, and proteins or amino acids. For instance, the enzyme carboxylase, which catalyzes the oxidation of pyruvic acid (one of the intermediate compounds in carbohydrate and protein oxidation), is a diphosphothiamine-magnesium-protein. The newer science of nutrition, which emphasizes the vitamins, minerals, amino acids, enzymes and coenzymes, and hormones, is mostly a product of the present century.

A historical review of the vitamins could begin with any one of many investigations and investigators. Following 1880, when rice polishing methods were perfected and polished-rice consumption became widespread in Japan and in the East Indies, beriberi developed there in epidemic proportions. This stimulated Eijkmann in Batavia, Takaki in Japan, and others to investigate the cause of this disease. Eijkmann, in 1897, fed polished rice to chickens, which promptly developed the nervous disease polyneuritis, similar to beriberi in man subsisting on polished rice. He explained the polyneuritis and beriberi, in harmony with the then prevailing general concept, by postulating that disease-inducing toxin was produced in the intestine of polished-rice consumers. Shortly thereafter a new concept appeared—that disease may be produced not only by the presence of harmful factors, poisons, and germs but also by the absence of indispensable factors. For instance, in 1905 Pekelharing, on the basis of observations on mice fed purified protein, fat, and carbohydrates, concluded that "there is a substance which even in very small quantities is of paramount importance to nutrition." In 1906 and 1912 Hopkins, on the basis of observations on rats fed purified protein, fat, and carbohydrates, concluded that the then known purified nutrients were deficient in "accessory food substances," which were present in milk. Osborne and Mendel reported similar results about 1911. Incidentally, the 1929 Nobel Prize in medicine was awarded to Eijkmann and Hopkins for these pioneer dietary experiments.

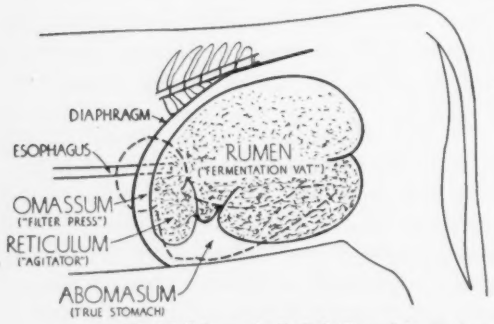
In 1911 Funk, then a 27-year-old Polish student at the Lister Institute in London, boldly formulated the theory that polyneuritis, beriberi, pellagra, rickets, and scurvy result from deficiency in the diet of specific chemical entities which he named vitamins. Funk, indeed, prepared a potent extract from rice polishings which cured polyneuritis in chickens fed polished rice. This extract is now known to have been rich in thiamine, nicotinic acid (identified by Funk who believed but did not prove that it was a dietary essential), and in other B-complex vitamins and minerals.

During the same period, E. B. Vedder and R. R. Williams in the Philippines were attempting to cure beriberi with extracts from rice polishings—attempts which led to the triumphant thiamine synthesis in 1936 by one of these workers, Williams, together with Cline.

In the meantime, beginning about 1907–09 (results published in 1911–15) Osborne and Mendel at Yale University and McCollum and associates at the University of Wisconsin employed purified nutrients in rat-feeding experiments, the results of which confirmed the preceding investigations that the then known purified nutrients were nutritionally inadequate and led to the discovery in milk of the fat-soluble vitamin A (McCollum and Davis, 1913; Osborne and Mendel, 1913) and a water-soluble vitamin B (McCollum and

Davis, 1915), now known as the B-complex vitamins. The essential nature of certain amino acids in the diet was likewise established during this period (Wilcock and Hopkins, 1907; Osborne and Mendel, 1911, and subsequent papers). The extremely widespread research interest in the "newer knowledge" of nutrition began with this very recent period.

The newer nutritional researches by thousands of investigators led to the classification of nutrients into four broad categories: substances yielding energy (including carbohydrates, fats, and proteins), amino acids (lumped under the heading "protein"), minerals, and vitamins. These four categories are known to include a half-hundred-odd distinct nutrients — including 22 known amino acids, 13 known mineral elements, 15 isolated vitamins, and an essential unsaturated fatty acid (linoleic acid, or linolenic acid, or arachidonic acid). New dietary entities, particularly B-complex vitamins and minerals, are being continuously discovered, which means that our dietary knowledge is incomplete, that we are not able to prepare a nutritionally complete "synthetic diet."



—Modified from A. F. Schalk and R. S. Amadon, N. Dak. Agr. Exp. Sta. Bull. 216, 1928.

FIG. 1. SYNTHESIS IN VIVO

THE MICROBIOLOGICAL SYNTHESIS OF B-COMPLEX VITAMINS AND AMINO ACIDS IN THE RUMEN OF CATTLE MAKES THIS SPECIES INDEPENDENT OF DIETARY B-COMPLEX VITAMINS AND AMINO ACIDS AND ADDS TO ITS REMARKABLE EFFICIENCY AS A PRODUCER OF ONE OF THE MOST COMPLETE FOODS, COW'S MILK.

An important recent development is that species differ in their dietary vitamin needs. For instance, vitamin C is apparently a dietary essential only for primates and guinea pigs. The other species investigated seem normally to synthesize this vitamin within the body, although not always to the optimal level. For the latter vitamin C is a *nutritional* essential, not a *dietary* essential; it is a hormone or enzyme component.

The vitamins of the B-complex, including thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, choline, biotin, the "folic acid" complex (including vitamin B_c, etc.), inositol, *p*-aminobenzoic acid, appear to be identical with the microbiologist's "growth factors," mostly members of "bios." About 1860 Pasteur observed that yeast required some factor for growth which Wildier in 1901 called "bios," later found by many investigators to include about a dozen distinct "growth factors." The recently-discovered B-complex vitamins are identical with the long-known microbiologist's bios factors, or growth factors, and are constituents of or associated with oxidation catalysts or enzyme systems in organisms ranging from bacteria to man. This means that there is an identity in oxidative mechanisms and nutritional (but not dietary) need in diverse organisms, ranging from bacteria to man. This identity of oxidative mechanisms in diversity of organisms is of great biological, chemical, and philosophical significance.

While the B-complex vitamins and amino acids enter into the nutritive processes of all organisms, some can synthesize them either directly as all green plants and most microorganisms do, or indirectly, as cattle do. Normally, cattle are not dependent on dietary B-complex vitamins and amino acids, not because they can synthesize them but because cattle—and apparently other ruminants—have in the rumen chamber of their stomach (Fig. 1) what is virtually a fermentation vat, with flourishing populations of microorganisms which synthesize the B-complex vitamins, especially in the presence of soluble carbohydrates. These microorganisms and their synthetic products are, in turn, used as food by the host organism. However, even some nonruminants, especially those with a large functional cecum, harbor microorganisms which synthesize to some extent B vitamins and amino acids. Even some human beings have good biosynthetic intestinal flora (Najjar and Holt). The nutritional condition of the animal is thus depen-

dent directly on the diet and indirectly on the nutrients synthesized by the microorganisms in the alimentary tract. Methods will probably be developed to make the rat or even man relatively independent of dietary B-complex vitamins and of some amino acids by developing foods which would stimulate maximal development of the most desirable biosynthetic microorganisms in their alimentary tracts.

The ideal diet, then, is one which includes not only nutrients needed by the animal but also nutrients needed by the symbiotic microorganisms in the alimentary tract. It is generally known that a high milk diet promotes a different intestinal flora than, for example, a high egg or meat or vegetable diet, with corresponding differences in biosynthetic activities. Dogs, for instance, are independent of dietary nicotinic acid, provided they are on a high milk diet which promotes niacin synthesis in the alimentary tract (Elvehjem). The lactose and, perhaps, to a less extent the butterfat in the milk favor the intestinal organisms that synthesize niacin, riboflavin, and other vitamins. The old idea of Metchnikoff concerning the profound influence of intestinal microorganisms on health and longevity may be substantiated, but more in the sense of nutrient biosynthesis than toxin inhibition.

The function of oil-soluble vitamins—A, D, E, K—differ in being, perhaps, more specialized than the water-soluble B-vitamins and not universally present in living organisms. Vitamin K is liberally synthesized by intestinal microorganisms so that, normally, it is not a dietary essential. The vitamin A precursor carotene is synthesized plentifully by most colored plants, which are the normal sources of vitamin A for herbivores and omnivores. Carnivores obtain vitamin A mostly from the livers of their victims, and omnivores may similarly obtain it. Vitamin E is also widely distributed in higher plants especially in the germ oil of wheat and other grains. Such microorganisms as yeast, rich in the B-vitamins, are probably devoid of and do not need the oil-soluble vitamins. As examples of the functions of the specialized oil-soluble vitamins: vitamin D increases calcium absorption and accelerates bone construction, and vitamin A is an essential constituent of the light-sensitive part of the eye, especially in night vision. Early vitamin A deficiency may be recognized by the slowness of adjustment of vision on entering a darkened room. However, vitamin A may also become a limiting factor in growth, reproduction, integrity of epithelial tissues (which serve as a barrier to infection), and development of teeth.

As already explained, plants and many microorganisms, and ruminants by way of rumen microorganisms, synthesize amino acids from such simple inorganic nitrogen compounds as urea, nitrates, and ammonium compounds. But rats and man do not, normally, synthesize what are called "essential amino acids." Of the 22 known dietary amino acids, 9 or 10 are dietary essentials for the rat—and probably for man—that is, they are physiologically needed but they are not synthesized by the body or by microorganisms in the alimentary canal in sufficient amounts. Of the remaining, 3 or 4 are partly dietary essential (they are synthesized, but too slowly for adequacy) and 9 are dietary nonessentials (they are synthesized in adequate amounts in the body proper or by microorganisms in the gut).

The nutritional value of a protein to nonruminants with simple stomachs, such as man, thus depends not only on its digestibility but also on its content of essential and partly essential amino acids. Since different proteins contain different proportions of the essential amino acids, proteins from various sources may supplement each other's deficiencies. For instance, cereals are poor in the amino acids lysin and tryptophane, while milk, egg, and meat are relatively rich in these amino acids. Hence, while different cereals do not correct each other's deficiencies, milk, egg, meat, and to a less extent, yeast, and some legume seeds, especially soybeans, do correct the amino acid deficiencies of cereals.

Of the thirteen mineral nutrients known to be essential (Ca, P, Mg, Na, K, Cl, S, Fe, Cu, Mn, Zn, I, Co) some are used for structural purposes, such as calcium and phosphate salts for bone; others are constituents of enzymes or hormones, such as iron in hemoglobin and cytochrome, magnesium in carboxylase, zinc in carbonic anhydrase, and

iodine in thyroxine; still others, including sodium, potassium, magnesium, and calcium, are involved in the regulation of physiological conditions, such as osmotic pressure, cell permeability and membrane potentials, colloidal condition, irritability of nerves, and contractibility of muscle. There is no dividing line between these functions. For instance, the phosphate radical serves as a structural constituent of bone and also of enzymes.

DIETARY deficiency of vitamins, minerals, or amino acids which function as essential parts in oxidative catalysts may be reflected in a wide variety of symptoms ranging from subclinical dermatitis and vaguely felt shifting pains to serious nervous and psychic disturbances as observed in advanced pellagrins and alcoholics. Pellagra may, indeed, begin with dermatitis, progress to insanity, and end with death. As previously noted, Eijkmann's classic experiments in feeding polished rice to chickens resulted in a severe nervous disturbance, polyneuritis. Why is the nervous system particularly affected by deficiency of vitamins and trace elements?

The basic fact is, of course, that nervous tissue is unable to function or even to maintain its integrity without continuous energy supply. This may be simply demonstrated by shutting off the oxygen supply and, therefore, the energy supply since energy is obtained by oxidation. The oxygen supply may be shut off suddenly by simple choking or by centrifugal drainage of the blood from the brain as currently experienced in fliers' "black out" or by inhaling carbon monoxide or hydrogen cyanide which combine with an oxygen carrier, hemoglobin in the first case and cytochrome in the second case. The extreme rapidity of onset of a "black out" is generally known. The effect of carbon monoxide, and especially hydrogen cyanide, inhalation is of the same order of rapidity (diving animals, such as whales, have special mechanisms for oxygen storage). The available oxygen may be reduced more slowly by dietary deficiencies, for example, by deficiency of iron, which is a constituent of hemoglobin and cytochrome, or by deficiency of thiamine, a constituent of the oxidizing enzyme carboxylase. The nervous and psychic symptoms associated with severe iron or thiamine deficiency are, then, similar in principle to those associated with decrease in oxygen supply by other methods, but the effects develop more slowly. Moreover, as previously noted, oxidation in the body occurs stepwise, and each step is catalyzed by a specific enzyme. For instance, if thiamine is lacking, the enzyme carboxylase is lacking, and the oxidation is blocked at the pyruvic acid stage. Consequently, there is not only a reduction in energy supply but also an accumulation of, and intoxication by, pyruvic acid and apparently other products of intermediate metabolism.

Under such conditions Zimmerman and others observed myelin and axon degeneration in the peripheral nerves and spinal cord and hemorrhage in the brain nuclei. The resulting disease may be polyneuritis in birds; beriberi, Wernicke's syndrome or Korsakoff's syndrome (otherwise known as alcoholic polyneuritis and whiskey paralysis) in man; Chastek's paralysis in foxes. Beriberi occurs among polished-rice consumers since the thiamine which is in the polishing is discarded in the milling process. Wernicke's and Korsakoff's syndrome may occur in chronic alcoholics, since alcohol is devoid of thiamine, and excessive alcohol consumption depresses the appetite for normal thiamine-containing food. Excessive consumption of alcohol or, for that matter, excessive consumption of any energy-rich but vitamin- and mineral-poor food may lead to dietary-deficiency diseases. Chastek's paralysis in foxes follows the feeding of raw fish which contains a thiamine-destroying enzyme.

The nervous system is the most sensitive to the absence of carbohydrate-oxidation catalysts not only because of its dependence on continuous energy supply but also because, as observed by Himwich, other tissues can use fat as energy source but the brain cannot.

Similar statements might be made concerning the effects of other mineral and vitamin deficiencies, but the function of thiamine is typical of the behavior of most other clinically important vitamins and minerals which function in oxidation processes. Indeed, the dietary-deficiency disease pellagra, often characterized by severe nervous and psychic

as well as dermal disturbances, is believed to be due to deficiency of several vitamins and perhaps some minerals and essential amino acids, although nicotinic acid is apparently the major deficiency.

Incidentally, psychic disturbances, such as mental confusion and disorientation may be similar, regardless of the causative factor. For instance, similar symptoms may be seen in severe anemia, poisoning, deficiency of thiamine, nicotinic acid, or other oxidative vitamins, severe infection, circulatory failure, and even in some cases of purely "functional" mental disorders. Man, characterized by a high level of neuropsychologic integration, naturally responds sensitively by psychic reactions to many causative agents, including nutritional deficiencies, of which deficiency of thiamine and nicotinic acid, as seen in beriberi and pellagra, are best known and most dramatic.

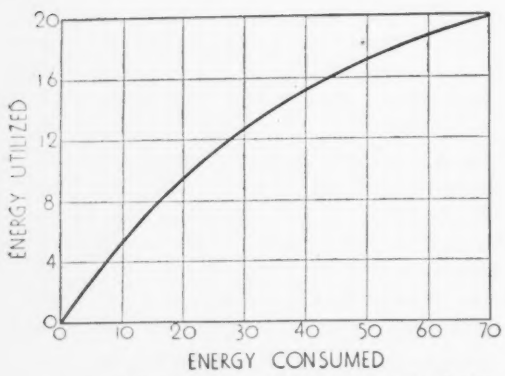
Vitamin A deficiency may also lead to disturbances of the nervous system but sometimes for different reasons. Wolbach and Bessey observed that vitamin A deficiency in the young retards the growth rate of the bony skeleton but not of the nervous system. The result is that the would-be normal growth of the nervous system is cramped by the retarded growth of the bony frame, with consequent damage to the nervous tissue. This may explain how animals may be born eyeless when their pregnant mothers are on a diet deficient in vitamin A. Under condition of vitamin A deficiency Moore observed constriction of the optic foramen in calves with consequent constriction of the optic nerve and blindness, and as previously noted, Warkany and others observed similar congenital malformations in other species.

The above discussion illustrates the fact that different dietary deficiencies and different basic causes may result in similar clinical symptoms; and depending on conditions, the same dietary deficiency may result in different symptoms. For instance, perosis, a disease of chickens, may be developed by any one of five dietary deficiencies: manganese, biotin, choline, and, according to unpublished observations by Hogan and Richardson, perhaps also by deficiency of vitamin B_6 and nicotinic acid. On the other hand, deficiency of vitamin E may cause widely different effects, ranging from impairment of fertility to muscular dystrophy and, in chicks, to a serious disease of the nervous system, particularly the brain. The same may be said about deficiency of other vitamins: vitamin A deficiency may lead to night blindness, conjunctivitis, or to total blindness (severe xerophthalmia or keratomalacia is common in South India) and it may cause sterility (degeneration of the germinal epithelium); pantothenic acid deficiency may lead to diseases ranging from dermatitis to cessation of growth; choline deficiency may lead to many disturbances including perosis in chicks, impairment of lactation, fatty liver, and hemorrhages of kidneys in the rat.

As previously noted, the effects of vitamin deficiency in man are known only for 6 or 7 of the 15 isolated vitamins: A, D, thiamine, riboflavin, ascorbic acid, nicotinic acid, and biotin. This problem is, moreover, confused by sparing, synergistic, supplementary, and antagonistic interrelations so that a change in the intake of one nutrient has a variable influence, depending on circumstances, on the effects of the others. For instance, dietary thiamine requirement is dependent on bacterial synthesis in the gut, which is, in turn, dependent on the fat and riboflavin content in the diet. The dietary manganese requirement is related to the thiamine intake. Pantothenic acid is similarly interrelated with riboflavin.

To cite endocrine interrelations, an overactive thyroid accelerates enormously the breakdown of all nutrients so that hyperthyroid individuals tend to suffer from all dietary deficiencies, including vitamins and minerals. On the other hand, vitamins A and C are said to counteract the effects of an overactive thyroid and of excessive thyroxin. The parathyroid hormone, vitamin D, and dietary calcium are also interrelated: animals without parathyroids may live normally but only on a very high calcium and vitamin D diet. A dramatic effect of a vitamin deficiency on endocrine function follows the elimination of vitamin E from the diet of the male rat; the germinal epithelium degenerates with consequent permanent sterility.

Another factor which confuses nutritional experiments is the effect of the quantity of food intake on food need. The less the food



—Based on a compilation of data by Forbes, by Mitchell, and by Wiegner on cattle and on rabbits.

FIG. 2. EFFICIENCY OF FOOD USE

THE FOOD UTILIZATION PER UNIT FOOD INCREMENT DECREASES WITH INCREASING FOOD INTAKE AS INDICATED BY THE WAY THIS CURVE FLATTENS OUT WITH INCREASING FOOD CONSUMPTION. IN OTHER WORDS, THE LESS THE FOOD INTAKE (WITHIN LIMITS) THE MORE EFFICIENTLY THE FOOD IS UTILIZED. FOR HUMAN NUTRITION THE CURVE IS NOT NECESSARILY THE SAME.

intake the less, within limits, the food needed. This interrelation is extremely important in permitting survival under adverse conditions, such as now prevail in the famine-ravaged war areas. The mechanism of this interrelation is relatively simple as regards dietary energy. Decrease in dietary energy is followed by loss in body weight, and the lighter the body the less is the energy required for its maintenance. Then, too, as illustrated in Figure 2, the less the food intake the higher its utilization efficiency. A striking illustration thereof in human nutrition in relation to dietary energy need was furnished by Benedict during the first World War when he reported that decreasing a man's body weight by about 15 percent may enable him to maintain the lighter body on nearly half the original dietary energy intake. Another illustration, by Mitchell and others, relates to utilization efficiency of dietary calcium. For instance, a child on a liberal calcium diet utilizes, perhaps, 30 percent of the calcium intake while one on a very low calcium diet may utilize 90 percent of the calcium intake; an adult on a liberal calcium diet needs about 10 mg. of calcium per kilo. of body weight, but one on a very low calcium diet may attain calcium equilibrium on 3 or 4 mg. of calcium per kilo. of body weight. The higher calcium utilization on a low calcium diet may be due to using over and over the calcium "waste," as occurs with the re-utilization of iron on a low iron diet. There is, however, a limit of re-using body waste. For instance, if the dietary energy or protein is reduced below a certain critical value, the body protein may be used for fuel, the blood protein may be reduced to an abnormally low level, and the serious condition called "famine edema" or "war edema" may develop.

An overt method of re-using body wastes for dietary purposes, one which gives a lot of trouble in vitamin research, is illustrated by experimental animals on deficient diets; they then resort very skillfully to coprophagy in an effort to supplement the deficient diet, despite the experimenter's ingenious efforts to prevent such dietary supplementation from feces. (Feces are normally rich in vitamins and amino acids synthesized by intestinal microorganisms and derived from the body proper, also in minerals, because calcium, iron, and many other salts are normally excreted by the body into the bowel. Indeed, cattle manure is used as a tonic for chickens and swine presumably because of its high vitamin and mineral content, and it is generally known that on many stock farms swine follow the cattle and chickens follow the swine in friendly symbiosis.)

The homeostatic mechanisms which serve to adapt the animal to dietary scarcity are useful from the survival viewpoint, although they may involve serious dangers to health. One may survive at least for a while and reproduce while suffering seriously from many dietary disabilities, ranging from loose teeth and constipation to insanity. The ideal, however, is the most advantageous long-range survival, what Sherman calls "buoyant health," which may often be attained by simple dietary means.

ARE there really simple dietary means for eliminating malnutrition on a national scale? If so, why is there such a high incidence of malnutrition? Are we wanting in the good will and patriotism required for adopting a simple means for abolishing malnutrition? These are problems of capital religious and national importance in peace as well as in

war. The answer thereto is like the one given in the author's essay (SM, September 1944) concerning maladjustments associated with the rapid development of science and technology. One may, perhaps, suggest again that since scientists are in a sense responsible for disturbed conditions associated with scientific and technological progress, they should properly assume leadership to promote the best use of their specialized knowledge, to humanize it and give it a social orientation, and to attempt to "make reason and the will of God prevail" (Matthew Arnold).

A simple solution comes to mind for our national malnutritional problem, which results from excessive consumption of denatured foods. The idea is not novel. Grocery stores sell inexpensive dietary-complete dog foods. Why not similarly inexpensive dietary-complete human foods?

It is suggested that a nationally available attractive and inexpensive milk-bread properly fortified with vitamins and minerals and perhaps garnished with such a food as raisins would eliminate malnutrition on a national scale. The reasons for suggesting milk-bread as a medium for a nutritionally complete food are: first, wheat and milk are the least expensive and most abundant foods of plant and animal origin—they provide the greatest amount of food per unit of agricultural resource in this country; second, whole wheat and whole milk in certain proportions constitute an optimal diet for rats (Sherman), and it is reasonable to assume that a wheat-milk bread, if fortified with vitamin C and other nutrients required in relatively greater proportions, would also be an optimal diet for man; finally, everyone eats bread anyway, especially the underprivileged who are the largest bread consumers and who are the special concern of research in national dietary welfare. Since the wealthy are said to obtain only about 15 percent of their dietary energy from wheat, it is less essential that their bread or cake be of good nutritional quality because they get their superior proteins, vitamins, and minerals from more expensive foods, such as milk, butter, cheese, meat, egg, fresh vegetables, and fruits. The underprivileged, on the other hand, omit the expensive "protective" items and concentrate on bread, starch, and sugar, which contribute, perhaps, 75 percent of the dietary energy. Members of the middle class are said to obtain over 50 percent of their dietary energy from white flour, starch, and sugar; that is, from foods which are seriously deficient in vitamins, minerals, and amino acids.

Other conditions being equal, whole-wheat flour and whole milk would be best for the proposed dietary-complete bread. They are natural foods in the sense that man has consumed them as they are in the course of his evolution. Nutritionists admit that they are not yet able to replace naturally evolved foods, such as milk and whole grain, by "synthetic" diets. The concept of "purity" has its place, but from the nutritional viewpoint such pure foods as sugar, starch, and patent flour are greatly inferior to whole-wheat flour with all its bran, middling, and germ "impurities." As Carlson has said, "nutritional safety lies in consuming, so far as possible, foods in their natural states." It is significant that the bread of Russian soldiers is made of whole-grain flour.

There is, moreover, every reason for believing that whole wheat is better utilized and is more valuable nutritionally than are the several wheat constituents when consumed separately and that, likewise, whole milk has a higher nutritive value than the sum of its constituents consumed separately. Furthermore, the nutritive value of whole wheat and whole milk when consumed together is greater than the sum of the nutritive values of each, milk and wheat, consumed separately. The various constituents are said to *supplement* each other, each supplying what the other lacks, thus enabling more efficient utilization of both.

White patent flour is inferior to whole-wheat flour because the milling process removes virtually all the vitamins, trace elements, and fiber. The parts discarded in milling—the germ, middling, and bran—carry with them most of the B-complex vitamins, minerals, and biologically superior amino acids, which are usually fed to cattle. As previously explained, cattle do not need dietary B-complex vitamins and amino acids and they obtain minerals from their basic roughage ration. Thus, the vitamins, amino acids, and minerals are taken from man who needs them and fed to cattle that do not need

them. This is certainly not a good illustration of human dietary wisdom. The following are examples of losses incurred in the patent milling process: 100 percent each of carotene, manganese, fiber, vitamin E; 85 percent each of thiamine, nicotinic acid, iron; 80 percent of ash; 75 percent each of copper, riboflavin, phosphorus, potassium; 50 percent each of calcium, pyridoxine, pantothenic acid, fat; 13 percent of the protein, and the amino acid relations of the remaining protein are seriously disturbed. There are, of course, many other losses.

The tenacious hold of the white flour products is due in part, as already explained, to its traditional or symbolic high prestige value; in part to its superior *culinary* qualities despite its very inferior *nutritional* properties; but mostly to its superior keeping qualities—it has no vitamins and minerals to support insect pests that infest whole-wheat flour, no oil to get rancid, and no protein-digesting enzymes.

It is, indeed, these superior keeping qualities of white flour and of other denatured cereal products that made possible the concentration of the milling industry into a few circumscribed areas that supply flour to the whole country. Whole-wheat flour manufacture, on the other hand, would have to be decentralized to the immediate neighborhoods of the bakeries, and the wheat grinding would have to be done shortly before baking. Advocating whole-wheat bread thus amounts to opposing a powerful industrial trend in a giant industry. This industrial trend is probably the underlying reason for the modern popularization of white bread and related cereal products by special sales techniques. This is a good illustration of how technical developments may exert unwholesome effects on general welfare. With the exception of oatmeal, which is virtually a whole grain, most of the packaged cereal products are nutritionally inferior to, although much more costly than, the original grains from which they were obtained.

"Enriched" white flour is merely flour from which two dozen odd nutrients are removed and to which only four nutrients—iron, thiamine, riboflavin, and niacin—are added to the level of the original grain. To characterize a seriously impoverished food as "enriched" is in a sense misleading. Even the short-time rat-feeding experiments by Morgan, Chick, Mitchell, McHenry, and others demonstrate that "enriched" white flour is no substitute for whole-wheat flour. The effects would have been much more striking if the rats had received this diet through several generations.

The white flour deficiencies are made good by the other foods in the expensive diets of the well-to-do, but not in the diets of the less privileged who lack the means for obtaining the protective foods. Many consumers, too many, attempt to make good the dietary deficiencies of their white flour and sugar diet by the use of expensive and perhaps harmful drugstore laxatives, vitamins, minerals, and so on. Even if we could—but we cannot—scientifically supplement the white-flour deficiencies with drugstore products, would it not be slightly absurd to remove the vitamins, minerals, and the laxative parts of the grain and then purchase them anew at many times the cost of the original constituents, especially in the case of those who cannot afford them? It is such considerations that suggest the great superiority of natural foods such as whole wheat and whole milk. Whole-wheat flour would supply energy, protein, B-complex vitamins, minerals, and bulk; milk would supply calcium, biologically superior amino acids, fat-soluble vitamins, and related substances deficient in wheat. No doubt there will be devised in the near future a stable ascorbic acid which when added to the mix would make the whole-wheat-whole-milk bread nutritionally complete for man. This bread could be further fortified with all other vitamins and minerals to such a level that when it supplies a third of the dietary calories, it would assure the full day's quota of the known vitamins and minerals, thus definitely eliminating, as far as humanly possible, nutritional deficiencies associated with the excessive consumption of white flour, sugar, and related highly purified—i.e., unnatural——forms of dietary energy.

Making available on a national scale the whole-wheat-whole-milk bread in the proportion of 80 percent whole-wheat flour to the equivalent of 20 percent whole-milk powder and fortified with a stable ascorbic acid and other vitamins as above described would be

the nutritional ideal. This ideal is not, however, likely to be adopted in the near future for the reasons given, especially because of the tendency for whole-wheat flour and powdered whole milk to spoil readily and because of the relatively high cost of whole milk, which is prized as a beverage and its butterfat as a spread. Since the whole-wheat-whole-milk bread ideal cannot, apparently, be achieved in the near future, the problem becomes one of finding a suitable substitute. The best substitute for whole milk is skim milk. While skim milk contains half of the energy of whole milk, it has all the water-soluble vitamins, minerals, protein, and lactose of milk. Consequently, *per unit energy,* skim milk is twice as rich as whole milk in the water-soluble vitamins and in the mineral and protein factors, and it is also fairly rich in choline. Thus, is it an ideal supplement to wheat flour in bread making.

Powdered skim milk is also very economical; prior to the war it sold at six cents a pound, not much above that of flour; so that replacing 2 ounces or 20 percent of the flour in a pound loaf of bread by skim-milk powder would not change appreciably the price of the loaf. Indeed, prior to the war bakers incorporated 6 percent of powdered skim milk in their "milk bread" without increasing its price. They did it partly because it greatly improved the yeast action with consequent production of a large loaf per unit weight of flour. Increasing the powdered milk to 20 percent of the flour improves the taste of the bread (to the writer's palate) but increases the density of the loaf because of decrease in gluten, which holds the air. The 20 percent milk-bread has more of the substantial solidity of "home-made bread" rather than the more aerial qualities of bakery bread.

If it is not practicable to use whole-wheat flour (I think it is; methods are being developed for permanent storage of perishable foods), it might be possible to use part whole-wheat flour and part white flour; or it might be possible to use flour containing 85 percent of the kernel instead of the 72 percent as is customary in white flour; or the usual white flour could be used, but the parts discarded in milling could be replaced by physiologically-equivalent supplements. For instance, about a half-billion pounds of wheat and corn germ are produced yearly and fed to livestock; similarly, large quantities of powdered brewer's yeast are produced as by-product of the brewing industry as well as directly for the drug trade. One or more of these could be added to the extent of 2 percent of the flour. Other products such as soy bean meal, linseed meal, peanut meal, tender dehydrated grass (cerophyll), middlings, or bran could be added in various amounts to the flour.

The problem is not one for an individual to solve. The National Research Council might appoint a special committee representing the milling industry, the dairy industry, the bakery industry, the consumer, the public health profession (it is a public health problem), the medical profession (it is a medical problem), the Surgeon-General (it is a military problem), the advertising profession (it is a publicity problem), as well as professional nutritionists, to develop a nutritionally complete bread to furnish all the needed "protective nutrients" and "bulkage" when the bread is consumed to yield a third of the dietary energy.

The national adoption of the proposed nutritionally complete bread, perhaps nationally subsidized and nationally advertised, might virtually eliminate the malnutritional toll, just as the incidence of infectious diseases has been materially reduced by national health measures and as the incidence of goiter has been reduced by adding iodide to table salt on a national scale. The prayer "Give us this day our daily bread" will then become scientifically as well as religiously meaningful.

(For story of Britain's National Bread, see next page.)

BRITAIN'S NATIONAL BREAD IN BALANCED NUTRITION

THE history of wheat bread in Britain during the past 75 years since the roller milling process came into general use has been a tale of increasing whiteness. Before the introduction of the roller mill, fine wheat flour of a creamy color had been obtained by repeated stone grinding, which reduced the wheat germ and inner portions of the pericarp to such a fine powder that they were not removed by the subsequent bolting process.

In the modern roller mill the germ is detached from the grain and flattened out on the rollers so that it is easily removed when the flour is bolted; the outer layers of the endosperm are also discarded with the bran. The use of chemical bleaching agents has contributed also to the whiteness of the flour and to some extent to its loss of nutritive value.

Until the end of 1939, flours for breadmaking were usually milled in Britain from blended wheats grown in different parts of the world and mixed so as to yield white flour almost constant in its baking properties. As much as 75 percent of the whole grain was obtainable in the form of straight-run white flour, though the usual prewar degree of extraction was 70 to 73 percent. For economy's sake this was increased to the full 75 percent shortly after the outbreak of World War II.

When, in 1940, it became necessary to conserve every available food resource, the Ministry of Food and the Medical Research Council considered seriously the problem of bread and flour in order that the highest possible yield of nutrients for man and animals might be obtained. From published analyses of milling products for mineral and vitamin content and from studies of the digestibility and nutritive value of protein and carbohydrate in breads made from flours of different degrees of extraction it was deduced that a flour representing somewhat more than 80 percent of the grain would contain satisfactory amounts of the most important nutrients. The results of experimental tests by British millers showed that a flour of 85 percent extraction could be obtained which would produce a satisfactory loaf of pale complexion and of high food value.

The Medical Research Council recommended the new flour and showed the advantages of its increased supply of vitamins and minerals. It was specified that the National Wheat Meal should contain 85 percent of the weight of the cleaned wheat and include all the germ and some fine bran.

Of the vitamins present in wheat the most important are those of the B group and vitamin E. As the latter is mainly present in the germ, use of bread made from this flour containing all the germ of the wheat may well be a significant factor in the general health of the people of Britain.

Extensive analyses for content of B vitamins have been made by chemical, microbiological, and biological methods on flours of different degrees of extraction. Tests on growth of young rats indicate substantial gain in vitamin content by increasing the degree of extraction of the wheat from 73 to 85 percent. The mineral content of 85 percent extraction flour is superior to that of 73 percent extraction flour with respect to calcium, phosphorus, and iron. In the former more of the phosphorus is in the form of phytic acid which binds calcium and renders it less easily absorbed, but this disadvantage was overcome by addition of extra calcium carbonate to the flour. The protein content of 85 percent extraction flour is usually greater than that of white flour and somewhat less than that of whole meal. The coefficients of digestibility of the proteins showed that national flour was about 3 percent less digestible than white flour, but this was compensated by its slightly higher content of proteins and their enhanced nutritive value.

Apart from its function in the wartime diet as source of calories and carbohydrate, the national loaf, as compared with white bread, has made a small extra contribution of protein and provided an important addition of B vitamins in the national dietary. It has been calculated that the normal adult requires about 1 mg. of vitamin B_1 daily; this would be supplied by 300 grams of national flour, roughly equivalent to a 1-pound loaf. The average daily consumption of bread in Britain is estimated at about $\frac{3}{4}$ pound a head, which would make a most important contribution of vitamin B_1 to the wartime diet.

The daily human requirement of riboflavin probably lies between 1.5 and 2.0 mg. A daily consumption of $\frac{3}{4}$ pound national bread would provide about 0.52 mg. The chief sources of riboflavin in the diet are cheese, milk, eggs, and meat, all of which are at present in short supply and are strictly rationed. Their probable daily contribution of riboflavin has been calculated to be approximately 0.6 mg. Here again the national loaf is important.

The decision of the Ministry of Food in October 1944 to lower the degree of extraction of the national flour to 82.5 percent and later, in January 1945, to 80 percent is regarded by nutrition experts with anxiety. Although it is possible that the vitamin B_1 content may be kept at a reasonably high level by a recent modification of the milling process, which insures the inclusion in the flour of the scutellum portion of the wheat germ that is specially rich in this vitamin, it is probable that there will be a serious fall in the riboflavin content. There is also the possibility that losses of other unrecognized dietary factors may also have occurred in the lower extraction flour.

In Britain the national loaf made from flour of 85 percent extraction has proved itself a staff of life of high nutritional value and general acceptability during four years of restricted wartime diet. During this period the good health of the people has been almost miraculously maintained, and apprehensions that gastric ulcers and other such conditions might be exacerbated by the browner bread have not been realized. On these grounds alone the use of bread of this type is to be commended, but consideration of the food shortage in the liberated countries of Europe where from necessity, even the bread is a strictly rationed article of diet provides additional reasons, both economic and humanitarian, for the most thrifty use of the wheat available.—HARRIETTE CHICK and ALICE COPPING, Lister Institute.

KEEPING AMERICA FIRST IN THE AIR*

THE NACA AND AERONAUTICAL RESEARCH

By JOHN F. VICTORY
SECRETARY, NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

THE overwhelming influence of German air power during the first year of the war in Europe awakened the American people to a great danger. With the invasion of France and the Low Countries the President sounded the burglar alarm with his call for 100,000 airplanes, and American industry responded with the miracle of aircraft production. No single measure has had more far-reaching effect in changing the whole course of the war. Subsequently, in the battle of Britain there was a demonstration of the relative value of superior numbers on the German side versus superior performance by Britain's aircraft. That test made it clear that the airplanes that America was destined to produce in great quantity must have superior performance. The dollar cost of the aircraft program was alone sufficient to require enormous expansion of the work of the National Advisory Committee for Aeronautics (NACA) in order to assure a sound return upon the investment. But in time of war money loses significance alongside the imperative military requirements for superior airplanes. Although the Congress, too, can seemingly work miracles in its field, it cannot legislate superior performance into an American airplane. But it can set science to work. It did so, and that is where the NACA comes into the picture.

The NACA was established by the Congress thirty years ago "to supervise and direct the scientific study of the problems of flight with a view to their practical solution." It is a committee of fifteen appointed by the President and serving as such without compensation. The membership comprises General Arnold and Major General Powers of the Army Air Forces; Vice Admiral Fitch and Rear Admiral Richardson; two officials of the Civil Aeronautics Administration; the heads of the Bureau of Standards, the Weather Bureau, and the Smithsonian Institution; and six technically qualified experts from private life.

Out of NACA research has developed the engineering basis for a rapidly advancing technology. Consequently, when the war started, America had a healthy nucleus of a strong, competitive aircraft industry. Had it not been so, we might now be studying German and learning how to do business with Hitler.

There is no natural law known that to-day fixes a limit upon either the speed or the size of aircraft. All types of American airplanes in production to-day, and many foreign types, make use of fundamental design data from the laboratories of the NACA. Let me emphasize, however, that in the development of America's air power the NACA has been only one member of the firm, a silent partner, so to speak, of the military services and of the aircraft industry. The over-all progress is the result of the organized effort of millions of Americans involving many organizations, governmental and private, including not only the military and manufacturing establishments directly concerned with aeronautics, but many supporting agencies and industries. Developments in aeronautics have been extremely rare for which any single organization or individual, in or out of the Government, deserves all the credit.

The airplane and the tank were introduced in World War I, but it remained for the present war to develop their dominant role. In like manner, we may expect that new weapons recently introduced in war may be but the forerunners of a whole new line of weapons that may dominate the future. Aviation is entering an era of revolutionary change resulting largely from the development of new methods of propulsion. The new propulsive systems open up extraordinary high-speed possibilities which must be studied and evaluated.

* From *The Torch*, July, 1945. Copyright by the International Association of Torch Clubs, Inc.

The country can be grateful to the Congress that had the vision to establish the NACA as a separate agency to advance aeronautical science, although that Congress was quite cautious about how it appropriated the taxpayers' money. It started the NACA with an appropriation of "$5,000 a year for five years, or so much thereof as may be necessary." It was not clear whether the phrase "so much thereof as may be necessary" related to the $5,000 or to the five years. However, with continued far-sighted support of the Congress, the NACA has grown from that modest start to an organization of 6,500 employees, with an annual operating budget of $26,000,000 and with major research stations at the Army's Langley Field, Virginia; the Navy's Moffett Field, California; and the Cleveland Municipal Airport, Cleveland, Ohio.

Experience through two great wars has enabled the NACA to blaze new trails in aeronautical research and to lay the foundation in America for the new science of aeronautics. Under the leadership of able chairmen from Dr. Durand in World War I to Dr. Hunsaker and including the illustrious names of Charles D. Walcott, Joseph S. Ames, and Vannevar Bush, the NACA, with the invaluable assistance of Dr. George W. Lewis as Director of Aeronautical Research, has worked as one with the Army, the Navy, and the industry to gain for America definite leadership in aircraft development.

America's leadership first became generally recognized in the late twenties. I recall that in the early thirties there was a meeting in the United States of the Federation Aeronautique Internationale. Discussions by European leaders after visiting the NACA laboratories at Langley Field were to the effect that America was at that time ten years ahead of any other nation in the development of aeronautics. I asked them to explain. They replied that if progress were to cease in the United States, and Europe were to continue at its own pace, it would take any European nation ten years to catch up.

Then came Hitler and the resurgence of German militarism. Setting about quietly at first to build a superior air force, Hitler authorized Goering and Udet to do all things necessary to build for Germany the strongest air force in the world. Realizing that the struggle for supremacy in the air must start in the research laboratory, Germany expanded and multiplied its research facilities until, at the time of the Pact of Munich in 1938, the German aeronautical research establishment had grown to five times the size of that of the United States. By that time Germany had also built its great air force and was then the strongest power in the air.

In 1937 the NACA anticipated the oncoming emergency and began to expand its research facilities. It is fortunate that these additional facilities were constructed in time to increase the effectiveness of the whole aircraft program in this war. Let us see how that has been done. The problems are too numerous to recount in detail, but a few examples can be given.

THE AIRCRAFT program required enormous quantities of aviation gasoline and lubricating oil, involving first of all a determination of the kind of petroleum stocks that could be used to produce high octane gasoline in the quantities needed.

In cooperation with the oil industry's laboratories and with the Army and Navy, the NACA was able to bring forth research data upon which decisions were based for the early expansion of the aircraft petroleum industry. The shortage of natural rubber made it necessary quickly to reach decisions as to the petroleum stocks to be used, and NACA research served as a guide by indicating how different products would perform in an aircraft engine.

The chief tool for aerodynamic research is the wind tunnel, which is, generally speaking, an apparatus or structure for measuring the various characteristics of airplanes under simulated flight conditions. Tests are made at the throat, or smallest section, of the tunnel where the air velocity is greatest. Throat sizes range from 4 by 18 inches to 40 by 80 feet, the latter being the largest in the world, and large enough to test a full size airplane. The NACA has in operation about thirty wind tunnels, used for different purposes; e.g., to investigate stability and control, to increase lift and reduce drag of wings, to

improve streamlining in general, to develop engine installations, to study propeller efficiencies, to make airplanes controllable when spinning, to prevent ice formation in flight, to improve operating characteristics at high altitudes, and to explore the possibilities and obtain fundamental data in the entirely new field of flight at speeds above the velocity of sound—roughly 750 miles per hour at sea level.

Speed is still the most important single characteristic of an airplane. Through the ages the speed of man's travel has increased slowly up to the time of the conquering of the air. Since then improvement has been rapid. One of the greatest developments in the evolution of the aerodynamic, or streamline, form has been the NACA high-speed wing. This wing makes possible under flight conditions as much reduction in wing drag, or resistance to forward motion, as all previous research had accomplished in this respect since the original Wright airplane first flew in 1903.

The first significant application of the NACA high-speed wing was in the P–51 Mustang. That airplane was voted by Europe's outstanding aeronautical experts as the best fighter airplane on either side in the European war. Since Pearl Harbor the NACA has investigated, on request of the Army alone, 42 types of bombers, 50 pursuit types, and about 40 miscellaneous types, and a comparable number for the Navy. As an example of what the NACA does on a new type of airplane, let me mention some other aerodynamic characteristics of the P–51 which are also the product of NACA research: air scoops to provide combustion and cooling air, which greatly reduce the drag of air intake openings as formerly used on airplanes; filleting, that is, the fairing at the junction of the wing and the fuselage; the windshield and canopy shape; NACA flush-type rivets; and improved controllability in dives. The NACA also provided the basic data for the design of exhaust stacks on the P–51 in order to get additional speed by the use of the exhaust as a form of jet propulsion.

The early versions of the Mustang had a 1,000-horsepower engine. The design of the airplane was such that no fundamental bar to speed-increase existed, so that when engines approximating twice the power became available, they were used. The resulting large increase in speed caused serious rumbling and strong vibrations around the radiator scoop. The causes were investigated by the NACA in a wind tunnel at 600 miles per hour. By application to the air scoop of the same principles that were used in the high-speed wing design the rumbling and vibration were cured. This simple improvement permitted a full realization of the speed possibilities of the Mustang design.

The basic principles of the NACA high-speed wing are gradually coming into general use on American airplanes where high speed is desired. The Bell P–59 Aircomet, the Bell P–63 Kingcobra, the Douglas A–26 Invader, and the Lockheed P–80 Shooting Star are mentioned as a few examples. The Shooting Star, a jet-propelled airplane recently announced by the Army, the Lockheed Company, and the General Electric Company, was investigated in model form in a wind tunnel at over 500 miles per hour to determine its high-speed control characteristics and to obtain an estimate of its performance. It was confirmed by those tests that the NACA high-speed wing, which the Lockheed Company had chosen, would permit the P–80, with its new jet power plant, to fly at a higher speed than any previous airplane. Extensive flight tests were made by the NACA Flight Research staff to correlate the performance data obtained in the wind tunnel and in flight and to make full-scale load measurements by recording the air pressures on the wings and tail surfaces during various high-speed maneuvers. This information is of exceptional value to designers because it is the first ever obtained at such high flight speeds. The NACA test pilot who conducted the flight tests on the P–80 flew, in those tests, faster than any other human being, without, however, bothering to establish an accredited world speed record.

As airplane speeds approach the velocity of sound new problems are encountered because the character of the air-flow over the wing, in obedience to natural law, changes abruptly at that speed and causes an im-

portant loss of lift and serious increase in drag.

Although the speed of any airplane can be increased through the simple use of more power, this method has serious limitations because constantly enlarging the power plant would increase weight and fuel consumption and reduce useful load. The major objective of aerodynamic research, therefore, is to increase speed by reducing the drag of the whole structure. The ability steadily to achieve progress in this direction has distinguished aviation from other forms of transportation. For example, to increase the speed of an ocean liner five knots would require twice the horsepower. To increase materially the speed of railroad trains would require not only more power but greatly improved road-beds and rolling stock. Likewise, to increase materially the speed of automobiles would not only take more gasoline and tires and cause more rapid depreciation and more accidents but would also require improved superhighways. On the other hand, the onward march of aeronautical science shows increases in speed being attained with increased efficiency. For commercial aircraft this will mean increased speed at less cost per passenger mile. And the more we learn to improve the performance of the airplane, the greater and more practicable of accomplishment seems to become the need for further improvement. Of course somewhere in the course of airplane development there will come into the equation some limiting factor of diminishing returns, which will impose a practical limit on speed and size. But, if we judge the future from the past we shall, as limits are approached, merely raise our sights a little higher and press for some further scientific development that will permit us to carry on.

As an example, the NACA has demonstrated by recent research that flight at supersonic speeds, that is, above the velocity of sound, is possible with new types of power plants and is conducting further research to make it an actuality.

Despite such development, large increases in drag will still occur at speeds between present flight speeds and supersonic speeds and represent one factor in hindering the immediate development of higher speed airplanes. It is essential that the drag of high-speed airplanes be made as small as possible. This problem is being intensively studied in high-speed wind tunnels and in flight, and considerable progress has already been made in the development of improved configurations not only for wings but also for fuselages, tail surfaces, cowlings, air intakes, windshields, and canopies.

The huge passenger airliners of the future may be powered by gas turbines of 5,000 to 10,000 horsepower per engine, using low-grade, nonvolatile fuel. The gas turbine has many fundamental advantages over the reciprocating engine. It has, for example, fewer moving parts, is considerably lighter in weight and smoother in operation, and its relative efficiency is superior at high altitudes and at high speeds.

The NACA is pushing research on the metallurgical and aerodynamic problems involved in the development of light, powerful compressors. Aircraft turbines will also require research to develop materials that will keep their strength at high operating temperatures.

The idea of a gas turbine has been known for two thousand years and has been used for at least a score of years in other forms of transportation and in stationary power plants. Why has it only recently attracted such attention that it is hailed as *the* engine of the immediate future for aircraft? One reason is that, since 1939, the NACA has initiated and sponsored research by others in the development of new alloys having high strength at high temperatures.

German turbine development so far has been accomplished without using such high-temperature alloys, but this has required a complicated system of cooling which would not have been necessary had they had our high-temperature alloys. Another NACA contribution was the improvement through research of the efficiency of supercharger compressors from below 70 percent to 85 percent, and higher. These improvements enabled us, after a slow start, to gain the lead in this most important field.

The NACA initiated steps for the development of jet propulsion in this country. Several years ago the NACA formed a Special Committee on Jet Propulsion and got three

large firms interested in accepting membership; namely, General Electric, Westinghouse, and Allis-Chalmers. As a result, each of these firms developed designs of jet propulsion units, two of which are now in production. The third seemed better adapted for postwar development and therefore has not been pushed.

Parallel with that activity, General Arnold saw what the British were doing with the Whittle engine, and in conferences with our committee it was agreed to get an American firm to manufacture the Whittle engine. The Army then made a contract with General Electric resulting in the production of this jet propulsion engine, which was first used in the Bell P–59 airplane.

Flowing directly from their original interest in the subject, the General Electric Company went on further and developed the jet propulsion unit now used in the Lockheed P–80 Shooting Star. In the P–80 we have something fully as good as, and perhaps superior to, either the German or the British jet-propelled airplane. The P–80 has been studied by the NACA to show where modifications could be made or must be made to obtain satisfactory performance at altitudes for both winter conditions and summer conditions.

There is no way to measure the value in war of superior performance of aircraft. It may mean the difference between winning and losing a war. The Battle of Britain in 1940 is a case in point. But the scientific research of the NACA has also a tremendous economic value which can be measured in part in dollars and cents. Take for example the B–29 which has so rudely awakened the Japanese leaders from their comfortable dream of world conquest by putting so many of their industries to sleep. That airplane is at present the great white hope of the Army Air Forces in the long-range bombing of Japan, although the Army has three new bombers coming along which are expected to be more powerful and capable than the B–29. They are the Consolidated B–32 (virtually a parallel project to the B–29), the Northrop B–35, and the Consolidated B–36, which is larger than the B–29. The American people are putting into the B–29 program alone several million dollars. Now what is the end product of that great expenditure? Transportation of bombs for long distances. Recent NACA research indicates a possible fuel saving which could very materially increase the return upon that investment either in terms of dollars and cents, conservation of material resources, or by making more bombings sooner to shorten the war. And that research cost only a few thousand dollars.

I might give another interesting example of research as applied to the B–29. That airplane was designed for a certain gross load. Military necessity required that it carry a greater load. As a result the engines had to produce more power, which resulted in their overheating. This in turn shortened their service life, sometimes caused failure in flight, and endangered the airplane and crew. NACA research showed where the overheating was critical and pointed to a partial remedy which is being applied and is resulting in greater safety in operation and considerable lengthening of the service life of B–29's.

One of the most serious hazards to flying is ice formation. The NACA Exhaust Heat De-Icing System for the Prevention of Ice Formation on Aircraft is being applied on several types of military aircraft now in production and has permitted safe flight in weather conditions which otherwise would have grounded airplanes. It is one of the greatest contributions to the safety of flying ever made.

The NACA altitude wind tunnel, just recently placed in operation at the Cleveland laboratory, is unique. It has been the most difficult project ever attempted in the realm of aeronautical research anywhere in the world. In an airstream twenty feet in diameter, flowing 500 miles per hour, there are maintained conditions of temperature and density existing at elevations up to 50,000 feet, i.e., about 67 degrees below zero (Fahrenheit) and a pressure about one-ninth of that at sea level. And this has been accomplished despite the fact that the power output of the engine under test and the energy of an 18,000 horsepower motor to create the wind must be absorbed as heat by the rarefied airstream while the temperature is kept at 67 below. The NACA Altitude

Wind Tunnel is the only place on the surface of the earth where the performance of jet propulsion engines can be investigated under altitude conditions. Without it, many months and the running of dangerous trials would be needed to obtain flight data that can be obtained with ease and safety in the altitude wind tunnel in a very short time. It should give America a definite advantage in the development of jet propulsion airplanes.

Whereas a year ago only a few types of airplanes in all the warring nations could attain a speed in level flight of 400 miles per hour, the United States, England, and Germany now have airplanes in the 500 mile-an-hour range. Now NACA scientists, and no doubt those of other nations as well, are preparing to enter the entirely new field of aerodynamic problems involving flight of aircraft and of guided missiles at speeds above the velocity of sound. In order to explore these possibilities the National Advisory Committee for Aeronautics is actually constructing new supersonic wind tunnels having airspeeds much faster than the speed of sound, ranging up to the neighborhood of 2,000 miles per hour.

IN TIME of war the NACA operates as a research and engineering facility of the Army and Navy. Its work is the most fundamental activity of the Government in connection with the development of aircraft, and its relations with the military services and with the aircraft manufacturing industry are constant and intimate. It is this teamwork that has made possible the great development of America's air power in this war. The results of NACA research will continue to be reflected in the steady improvement in the speed, range, carrying capacity, stability, controllability, maneuverability, ceiling, rate of climb, and, in short, in the general military effectiveness of America's aircraft.

One of the outstanding lessons the present war teaches is that the problem of insuring America's future security is inseparable from the problem of keeping America first in the air.

NACA research on military problems will be largely applicable to commercial and private aircraft after the war, with this significant distinction: In military aircraft superior performance *must* be achieved, if at all possible, even at the expense of lowered safety and economy. In the development of civil and commercial aircraft the research emphasis must be primarily on safety and economy of operation.

Following the war, the world will enter the aerial age about which men have dreamed. Air transportation to all parts of the world will shrink time and distance and bring the peoples of the earth closer together in forceful emphasis on the fact that we all live in one world. Underwriting America's future in the aerial age and underwriting America's investment in such future preparedness in the air as will effectively preclude attack is its liberal support of research in aeronautics. America's aeronautical research policy is thus, in the military sense, an insurance policy on the very life of the nation; and in the commercial sense it is a sound investment assuring America a position in the forefront of progressive nations when the progress of civilization is resumed after the war.

NACA's John Stack, Chief of the Langley Laboratory's Compressibility Research Division and recognized authority on high-speed problems, indicated in the last Annual Wright Brothers Lecture the possibility within a few years of aircraft traveling westward at "clock-stopping" speeds. This would mean a speed at our latitude equaling the earth's speed of rotation on its axis and giving the effect of keeping the sun in a fixed position. In other words, regular air transportation leaving Washington, say, at 12 noon would arrive at San Francisco at 12 noon the same day!

SCIENCE ON THE MARCH

ATOMIC THUNDERBOLTS

JUST as people recall the circumstances under which they first heard the news of the attack on Pearl Harbor, so they will remember how the atomic bomb first burst upon their consciousness. In the Brownstone Tower the news came in the form of a telephone call from New York, early in the afternoon of August 6. The editor of a weekly wanted a photograph of Dr. J. R. Oppenheimer to run on the cover of his magazine. Could we provide a print of his photograph, which was published on page 574 of the SM for June 1941? Unfortunately, we could not. Later in the day we read a mimeographed news release entitled "Statement of the Secretary of War," and then came the newspapers.

We have no information about the atomic bomb that has not already been printed and broadcast everywhere. On the other hand, we could not disregard in Science on the March such a world-shaking stride in applied science. We can at least point out to our readers that they can prepare themselves for better understanding of future articles on release of energy from the nucleus of the uranium atom by reading or re-reading the brief article by Herbert L. Anderson on "Progress in Harnessing Power from Uranium" (SM, June 1940, pp. 570) and continuing on to the next article "Is Atomic Power at Hand?" The latter is an illuminating discussion of the subject by Robert D. Potter, who is both a physicist and one of the leading science news writers of this country. He should now rank as a prophet for he wrote:

> If the chain reaction of having one uranium atom split and liberate the neutrons which will split another one nearby, and so on, can be controlled, then a compact power source for military purposes could be achieved despite whatever the cost might be. Things which are uneconomical in a peacetime sense become practical for military services if they can perform tasks not possible, or carried out as easily, in any other way. No price can be put on such developments that might save the life of a nation that owned the discovery, anymore than one can put a price on a surgical operation which saves a man's life.

The dream of utilizing energy released by disintegration of atoms originated long before the 1939 discovery of the fission of uranium atoms by neutrons. No doubt it occurred to the first investigators of radioactive elements. An expression of this dream, so lately come true, may be found at the end of an article by L. R. Koller of the General Electric Company on "The Radioactive Elements" (SM, July 1928, pp. 54–56). Dr. Koller wrote:

> If we but knew how to control disintegration of this [atomic] kind and cause it to take place at will, the engineer might find in a few grams of matter the energy for which he now has to consume tons of fuel, and our whole economic system and daily life might be revolutionized.

Little imagination is needed to picture the destructive and possible constructive effects of controlled release of atomic energy. Will it be used for the good of the human race? Grave doubts are in many minds, and science is being regarded both with greater respect and with greater apprehension than ever before. It is appropriate that Dr. Weltfish's proposed oath for scientists should appear in this issue, because scientists should accept partial responsibility for the social consequences of the applications of scientific knowledge.

Many people, staggered by the implications of the atomic bomb, may feel that the advancement of science no longer needs any encouragement—that retrogression might be desirable. That notion, we think, is understandable but utterly wrong. If most citizens of the important countries of the world were equal in intellectual and ethical stature to those whose names appear in "American Men of Science" danger of misuse of atomic power would not exist. The most important fruits of science are the character and way of life of scientists; the material results of scientific knowledge are but by-products. It seems fair to conclude, therefore, that science should be advanced more rapidly than ever if the peoples of the world are to attain adequate respect for truth and sufficient understanding of man and nature to avoid catastrophe.

However deplorable the human deficiencies that made it necessary for American and British scientists to develop the atomic bomb, we must admire their glorious achievement. In the simpler days of old, it is said, Prometheus stole fire from the ruler of the gods and gave it to man for his use; now modern Prometheans have raided Mount Olympus again and have brought back for man the very thunderbolts of Zeus.—F. L. CAMPBELL.

DEFOLIATION OF PLANTS FOR PROFIT

THE phenomenon which occurs in green plant-leaves whereby carbon dioxide from the air, water from the soil, and energy from the sun are elaborated into sugars is, no doubt, the most important reaction known to man. Our food, heat, clothing, and shelter are practically all the direct or indirect results of this photosynthetic reaction. It is in the younger leaves of plants that most of the photosynthesis occurs, whereas the more mature leaves usually serve chiefly as organs of water and food storage for the plants.

In spite of their necessity and great importance in maintaining life on the earth's surface, the leaves of many deciduous crop plants reach a certain stage of maturity each season when they become useless and often are a detriment, rather than a help, to the production of seed, fruit, or fiber.

Too many large leaves may delay maturity of the early fruit. This is especially true of cotton, which is a perennial in its natural habitat, but in most countries is commercially grown as an annual. In a great many seasons the usual abundance of leaves prevents air circulation and sunlight from properly maturing the early fruit and boll rot often results.

In most seasons the seed of the soybean dries out on the plant only very slowly, and harvesting is consequently delayed. This is largely because the loss of water by transpiration forces the leaves to continue to pull water from the soil through the plant stems long after these same leaves lose their usefulness in increasing seed production. The harvesting of many crops is often hindered and delayed because of the presence of either fresh green or dry leaves. This applies particularly to the mechanical harvesting of cotton and grain crops. In the case of tomatoes, which require bright and direct sunlight for quick, full red-color ripening, late, abundant foliage may protect the fruit from this light so fully that harvesting is delayed until a considerable portion of the crop is lost by frost.

The necessity for some kind of foliage control to facilitate harvesting was brought to a focus in the development of the mechanical cotton harvesters. Getting rid of dried leaves and avoiding the chlorophyll stain on the fiber caused by crushing green leaves gave the engineers much worry. It had long been known that many chemicals will kill leaves, but they also kill or adversely affect the remainder of the plant. It is also a matter of common observation that when foliage is harmed in some manner, the plant will shed it and produce new leaves if growing conditions are favorable, and if the plant is not too nearly mature.

Leaf shedding is a normal growth process and is accomplished by the natural growth of a layer of abscission cells at the juncture of the leaf petiole and plant stem. Obviously, the phenomenon occurs only when the plant itself is unharmed. Defoliation by chemical means requires a compound which will stop the life functions of the leaf cells but will not damage the petiole nor be translocated, in harmful form, from the leaf to the plant stem and roots.

A chemical dust, now on the market and in which calcium cyanamide is the active ingredient, fulfills these requirements for a number of plants. Applied dry on leaf surfaces, when dew is present or when dew will form in a few hours after treatment, it quickly combines with water and interferes with the respiration of the leaf cells, causing cell deterioration, but does not harm the leaf petiole or stem of the plant.

The active chemical causing this lethal effect on the living cells is not stable. By the time the leaf cells are killed it has further reacted with water to form harmless compounds which are not translocated from the leaf to the stem of the plant. The plant is left unharmed and immediately sheds the damaged foliage by natural growth processes.

When other more stable toxic chemical compounds, which are known to be harmful to plant cells, are applied to plant foliage

they slowly kill not only the leaves but also the petioles and the plant stems. The extent and rapidity of the killing depends on the concentration of the material applied, the susceptibility of the plants involved, and the period in the growing season. They do not cause defoliation because they kill not only the leaves but also that part of the plant where the abscission cells are grown—"freezing" of the dead, dry leaves on the plant usually results.

The removal of plant leaves with this chemical dust is not entirely a chemical reaction. To grow abscission cells and shed its leaves a plant must be in growing condition. If, for example, a plant has been subjected to such severe drought conditions that it does not, each night, recover from its daily wilt, defoliation will not occur. A week or so after such plants are reactivated by rain or irrigation, they defoliate readily.

When crop plants are defoliated in late season, the conditions for growth of new leaves (long days, optimum temperatures, and sufficient moisture) are usually so unfavorable that they are not produced or, if so, they do not grow in profusion. As a consequence, the fruit or seed on the defoliated plant matures much more rapidly and is ready for harvest at a much earlier-than-normal date.

One of the greatest advantages of cotton defoliation is the avoidance of crop loss, due to boll rot, through which as much as 50 to 60 percent of the crop may be lost in some years. Cotton sets its earliest and best bolls in the lower part of the plant. In normal to wet years the foliage growth is often so luxuriant and heavy that the fiber in these early-opening bolls rots because it does not get enough direct sunlight and air circulation to dry out each day. As soon as the plants are defoliated all boll rotting is stopped.

With the leaves off the plants, the late bolls open up more readily and a much higher percentage of the total crop can be harvested in one picking. This always improves the grade of the cotton because the harvest is completed so soon after the bolls open. With no leaves to hide the bolls, hand-picking is facilitated. Work can be started earlier in the morning because, due to the absence of foliage, the cotton dries out so much more quickly and is ready to pick.

Both green and dried leaves have been a handicap to the mechanical harvesters. If green leaves are mashed by the mechanical pickers, a chlorophyll stain is left on the fiber which is almost impossible to remove. These stains show up in cotton cloth and do not take dyes the same as the unstained part. In the past, mechanical strippers were not used until after the plants were defoliated by frost. This always meant late harvests and much loss of grade in the cotton because of weather exposure of the opened bolls. With chemical defoliation this type of harvesting can be started two to three weeks before frost, and the entire crop can be gathered before bad weather sets in.

Where hand "snapping" or "stripping" (pulling off the whole boll) is practiced, laborers working in defoliated fields can harvest practically twice as much cotton in a day as in fields where the foliage is left on the plants.

Many entomologists believe that destroying cotton leaves in early fall will assist in boll weevil control, because the late broods of weevil may go into the winter in a starved condition and many may not survive. As a control measure, in Lower Texas where the pink bollworm is slowly spreading, the law requires that all cotton plants be destroyed, or plowed under, by September 1. Defoliation benefits these Texas cotton growers because it enables them to start harvesting at an earlier date.

Some growers believe that where cotton is grown under irrigation maximum yields have not been attained. The large amounts of water and fertilizers required for highest yields have not been used because they would cause excessive foliage growth. Now that the foliage can be eliminated in the fall, before it causes damage to the opened cotton, these growers believe they can increase yields to as much as three bales per acre.

Cotton leafworms are frequently a serious pest in cotton-growing areas. In only moderately heavy infestations these worms defoliate cotton plants about as completely as it is done with chemicals, and with similar effects. However, the final result is most unsatisfactory because of the damage to,

and grade lowering of, the fiber caused by their excrement. If heavy infestations of this pest are imminent, chemical defoliation of the plant robs them of their food and keeps the cotton fiber clean.

The Midwest soybean acreage has been greatly expanded because of the war, but farmers have not yet found the proper place for this crop in their usual rotations. Wheat should logically follow beans, but the latter mature so late that the best wheat seeding dates are past before the beans are ripe enough to harvest and store. Soybeans cannot be safely stored until their moisture content is down to 13–14 percent, and with the leaves on the plant the seed does not reach this low moisture level until late in the season. Chemical defoliation of the plants any time after the seeds lose their green color causes rapid loss of moisture without reduction in yield or quality of seed.

The date of safe harvesting is, consequently, advanced a few weeks, and the harvesting operation is greatly simplified because there is much less quantity of plant material to go through the combining machine. In years of bad weather in late fall and early winter many beans are lost by storm damage because they cannot be harvested early. Defoliation permits of harvesting before the average dates for damaging storms.

Throughout the northern states and in areas on the West Coast it is quite common for tomato growers to lose a large percentage of the fruit already produced on the plants because they do not ripen before frost. With declining temperatures and decreasing hours of intense sunlight in early fall days, the fruit on tomato plants with heavy foliage does not rapidly take on a full red-ripe color so necessary for high quality. If left in the field long enough for this color to develop, the fruit is often lost through frost. Commercial canneries oftentimes can operate only half time in late season because tomatoes do not ripen rapidly enough to keep them busy. Defoliation of tomato plants after the fruits are full sized greatly hastens ripening without reduction in yield and prevents crop losses due to unfavorable weather.

Nurserymen, who grow deciduous fruit tree stock, often have difficulty in getting the young trees to mature early enough in the fall for timely digging and storing. Defoliation of this stock, after the season's growth is made, induces early maturity without harm to the young trees—as a result, the stock goes into storage in good condition at an earlier date and the harvest labor is spread over a longer period of time.

The leaves of some crop plants such as cotton and tomatoes can generally be removed by applications of only 30 to 35 pounds per acre of defoliant. Soybean foliage, on the other hand, is more resistant and applications of as much as 100 pounds per acre are sometimes required if the plants have been toughened by dry weather.

Even distribution of the material so that some of the dust falls on each leaf is of utmost importance if complete defoliation is desired. Those leaves on a plant which do not get any of the dust are entirely unaffected by the application. If the dust can be sufficiently well controlled, selective defoliation of any portion of a susceptible plant can be practiced. This, however, is almost impossible under field conditions.

Airplane applications of defoliant dust have been completely satisfactory when experienced operators did the work. Pulling ground-dusters through the mature crops sometimes causes moderate loss by mechanical injury to the plants, but this means of application is widely used where airplanes are not available.

Defoliation experiments are under way on an expanding number of crops and plants on which the foliage serves no useful purpose after a certain date and which may delay and interfere with harvest, lower the crop quality, or harbor harmful insects.—M. V. BAILEY, Director of Agricultural Research, American Cyanamid Company, New York, N. Y.

BOOK REVIEWS

FROM FUNCTIONALISM TO CULTURAL DYNAMICS

The Dynamics of Culture Change. Bronislaw Malinowski. 171 pp. 1945. $2.50. Yale University Press, Connecticut.

BRONISLAW MALINOWSKI was an outstanding figure of recent anthropology, and his death has deprived the discipline of one of its most provocative and stimulating personalities. Trained as a physicist, his interest in the social mechanisms of human life turned him to anthropology, and the outbreak of the last war found him in the Trobriand Islands, on the extended field trip that was to be so important in shaping his thought. For out of the experiences of these three years of living with the people of the small community where he worked, and the intensive researches he made into their customs, he evolved the approach toward the study of culture he called functionalism.

This approach was in line with the *gestalt*-type of thinking prevalent at the time of its enunciation in the middle twenties, and, as in all the sciences, represented a reaction against the atomistic approaches that preceded it. The term functionalism caught on immediately, and the reports on various aspects of this field-work that began to come from Malinowski's pen received a wide and sympathetic hearing. The first of these works, entitled "Argonauts of the Western Pacific," was an analysis of Trobriand economics, an aspect of native culture that had been quite neglected by anthropologists to that time, incredible as this may seem today. Later came an analysis of Trobriand social structures and marriage customs—a notable contribution to perspective in the field of psychoanalysis—studies of the myths of these people, and of other phases of their existence.

Malinowski was never content merely to describe the life of the people among whom he had worked. His fertile mind was ever in search of new relationships, so that he invariably drew generalizations from his data that might be tested in other societies. Indeed, one criticism that was most often laid against him was that he saw the whole range of non-European cultures in the light of a single tribe—a criticism that was perhaps more inspired by those who were stung by his biting comments than by reason of the generalizations themselves, which, in fact, showed the insight of their author by the extent to which they proved to be valuable working hypotheses. Functionalism, however, was essentially a method, and it was the application of this method to wider fields that brought his attention to Africa.

For Africa, with its vast spaces, its great resources, and its numerous populations, was of far more consequence in London, where Malinowski held his professorship, than an obscure islet off the coast of New Guinea. Under his direction were the Fellows of the International Institute of African Languages and Cultures, and through directing their work he came to know, at once removed, the cultures of British Africa. His one trip to the continent was in the nature of a survey; it was confined to East and South Africa, and no intensive work was included in it, though "spot" studies, the results of which he never published, were carried out.

Unlike the Trobriands, where isolation had permitted the culture of the native folk to remain stable and relatively undisturbed, Africa, over all its enormous bulk, was in the throes of cultural change, the result of the impact of European expansion and imperialism on native life. Here tribes, numbering tens and hundreds of thousands, confronted new techniques, were required to make new economic orientations, adjust to new value-systems and a new world view; and all this under conditions that could only spell demoralization. Malinowski felt this as a challenge to him as a scientist, a teacher, a humanitarian, and accepted it by advancing the doctrine of what he termed "practical anthropology"—the anthropology of the changing native which should be as alert to the need for prescribing programs of action as to the discovery of scientific truth.

But Malinowski was deeply attuned to thinking in terms of a system of thought derived from study of an adjusted, conservative, small community. His theory of functionalism, was essentially ahistorical, if not

antihistorical, as his writings demonstrate in the many passages containing severe criticism of diffusion studies, of historical reconstructions, of any consideration of the factor of time depth in the analysis of human culture. For culture was to be considered in terms of the interplay and interrelation of its aspects, which functioned in their entirety so as to make a well-integrated whole that filled the life of a people, giving it meaning for them and affording them the satisfactions they grew up expecting to obtain in their society.

Africa, however, was dynamic. Cultural change, not stability, was the outstanding aspect of its social life. And in this situation, where the factor of time was paramount, the ahistorical system of functionalism did little to facilitate study. Malinowski's students did achieve brilliant results, and though they employed the term functionalism diligently in their writings, one has the impression that they achieved these results not because of their theoretical approach but because Malinowski, a magnificent teacher and field-worker, trained them to observe and report the facts as they found them, irrespective of the frame within which they worked. For Malinowski himself was never really at his ease when he considered the African field. His writings on the subject have a strident quality never found in his earlier work, as though his arguments were directed toward convincing himself first, the reader only secondarily.

The volume here under review, which has inspired these reflections, represents passages from his published discussions of the anthropology of cultural change, finished pages for the work this book was intended to be, and materials in note form. These were assembled with devotion by one of his students, Dr. Kaberry, who though a specialist in Australian anthropology, did remarkably well in what must have been a most difficult task in handling such fragmentary materials relating to African problems. But the work does not come off. I, for one, prefer to think of Malinowski's contribution as he made it in the exciting pages where he hammered out his theory and method of functionalism; where with dry humor and incisive analysis, he stripped pretention to its sterile reality and joined others in infusing life into what should be the most living of sciences, the science of human civilization. It is little service to his memory to present his jottings to the world. His contribution will live long, but this work will not be a part of it.

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A TAXONOMIC GUIDE TO SOIL FUNGI

A Manual of Soil Fungi. Joseph C. Gilman. 392 pp. Illus. 1945. $5.00. The Collegiate Press, Inc., Ames, Iowa.

THE author of this volume is one of America's well-known mycologists, with years of experience in teaching and research. He has long been especially interested in the fungus flora of the soil. In 1927, in collaboration with Dr. E. V. Abbott, a colleague at Iowa State College, he published a paper, "A Summary of the Soil Fungi," in which the effort was made to provide a taxonomic key to all the species of fungi known to have been isolated from the soil. The paper was based in part on their own study of the fungi of Iowa and Louisiana soils during the preceding five-year period. The paper proved useful to investigators in the field of soil microbiology, as well as to workers in industry and medicine. Impressed by the demand for separates, indicating a growing need for such a publication, Dr. Gilman undertook its revision and now presents it in book form, brought up to date and greatly amplified by the incorporation of much additional information taken from the mycological literature of the intervening years.

As emphasized by its author, the book is largely a compilation. The species of fungi included in it are those which have been recorded in the American and foreign literature as having been isolated from the soil. The treatment is strictly taxonomic. A detailed technical description of each species is given, accompanied by citations to the publications in which its isolation from the soil has been reported. Dichotomous keys are provided to aid in the identification of unknown material in hand. The reader is assumed to have knowledge of the techniques employed in pure culture studies of the fungi, no information being provided con-

cerning them. The species included in the manual are chiefly those that have appeared in plate cultures made from soil samples. Few of them have been observed growing in the soil itself. Some have been isolated repeatedly by various investigators. Many others seem to have been included in the book on the basis of a single record. Species which do not develop in the fruiting condition on the usual types of artificial media are automatically excluded from consideration. The terrestrial mushrooms and the many other soil-inhabiting *Basidiomycetes* and *Ascomycetes* are in this category. The only member of the *Basidiomycetes* to be found in the volume is *Pellicularia filamentosa*, easily recognizable in the mycelial condition and long known as *Rhizoctonia solani*. Though *Sclerotium rolfsii* is given a place, none of the other sclerotial fungi of the genera *Sclerotium, Sclerotinia, Botrytis, Typhula,* etc. are included. The *Actinomycetes* and *Zoophagaceae,* unquestionably important soil fungi, are intentionally omitted. So also are the yeasts. Plant pathogens considered to be soil borne but which have not been reported as having been isolated directly from the soil are excluded. The same is true of the large number of species recorded as growing in leaf mold, decaying wood, and other similar substrata not yet completely incorporated in the soil.

The *Ascomycetes* are covered in twenty pages of the text, descriptions of four *Discomycetes* and twenty *Pyrenomycetes* being provided. Ten of the latter are species of *Chaetomium*. The material on the *Phycomycetes* covers 133 pages. The treatment of the *Mucorales,* based on that of Zycha, is relatively extensive, embracing nearly one hundred species, forty-one of which are members of the genus *Mucor*. The *Saprolegniales* receive more space than was to have been expected, sixty-one pages being given to the presentation of lengthy descriptions, most of which seem to have been copied essentially verbatim, with the consent of W. C. Coker, from his well-known book. Though the manual includes descriptions of fifteen species of *Pythium,* the absence of reference to any of the papers of Drechsler emphasizes the point that species stated to have been isolated from diseased roots, bulbs, or plant debris, rather than from the soil, have for that reason alone been omitted. Though species of many genera of the Fungi Imperfecti are incorporated, they are almost exclusively members of the *Moniliales* (*Hyphomycetes*). Moreover, of the 187 pages given to this group, a total of 111 is used for detailed descriptions of 124 species of *Penicillium,* 32 of *Aspergillus* and 41 of *Fusarium*. The diagnoses of the *Penicillia* and *Aspergilli* are copied chiefly from the two well known volumes by Thom, and Thom and Church respectively, while the descriptions of the *Fusaria* are translations of those in Wollenweber and Reinking's "*Die Fusarien*" used by permission of the Alien Property Custodian. Similarly, keys and descriptions are taken from Zycha's "*Mucorineae.*" The professional mycologist and others to whom the original papers are available will doubtless prefer to consult them, since they are more inclusive and more adequately illustrated. Workers dependent largely on the manual for their taxonomic information concerning the fungi will, however, find themselves provided with many thoroughly reliable and adequately detailed descriptions prepared by specialists on the largest and most difficult genera.

In his introduction Dr. Gilman points out that many of these so-called "soil fungi" have air-borne spores which are widely disseminated and germinate to produce mycelium and form spores again on many sorts of substrata. They cause spoilage of stored foods, cloth, paper, cork-products, wallboard, leather goods, and even casein paints. They are, therefore, not exclusively soil fungi, and they have a much wider interest and greater importance than results from their significance in connection with the problems of soil microbiology. During the present war the molding and decay of tent fabrics and many other materials in use by our army and navy under exceptionally humid conditions in tropical climates has brought these molds sharply to attention. Trained mycologists are serving in laboratories established by the armed forces for the study of these fungi with emphasis placed on the development of preventive measures designed to reduce the loss in time and materials resulting from their attacks. In in-

dustry and medicine also the molds have gained enormously in practical significance in recent years, and an increasing number of research workers are engaged in the study of vital problems involving a knowledge of the identity of the various species as well as of their physiological activities.

Information concerning the morphology and taxonomy of the molds is scattered through many publications, some of which are not available except in the larger libraries that have specialized in their accumulation. There has been no single volume to which the average worker could turn for a reasonably adequate treatment of these fungi. The appearance of Dr. Gilman's attractively bound, clearly printed, and carefully prepared volume is well timed, and we predict a good sale for it. The book fills a distinct gap in the mycological literature and meets at least partially a very definite need. Moreover, it contains an extensive bibliography of 169 references to many of the other significant taxonomic publications. A glossary of technical terms is appended and an adequate index is provided. The generic characters are illustrated by 135 small pen sketches.

The reviewer feels that should a second edition be prepared the author might well give consideration to the advisability of providing more abundant illustrations designed to aid in the separation of species. He feels also that the title selected for the book is misleading since many of the species included are no more typical of the soil than of many other substrata. Moreover, since the appearance of a mold colony on a plate culture made from a soil sample fails to provide proof that the organism is a member of the normal fungus flora of the soil, the criterion used for selection of the species incorporated in the volume seems lacking in any fundamental significance. The book would have been considerably more valuable to the plant pathologist than it is if descriptions of soil-borne pathogens such as species of *Phytophthora* had been included.

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JET PROPULSION THEORIES

The Coming Age of Rocket Power. G. Edward Pendray. 244 pp. Illus. 1945. $3.50. Harper and Brothers, New York.

THE character of this book is indicated by the statement on its last page ". . . those of us who have spent years in the study and development of rockets have acquired an emotion about them which is almost religious." This attitude is not one which could produce an analytical study, but is admirably suited to fantasy and speculation. The book is primarily a statement of what a rocketeer feels that the rocket will be able to do rather than an attempt to ascertain its foreseeable developments in the not-too-distant future or its ultimate limitations.

The principal contribution of the book is the historical part dealing with the origin of the rocket, its use in the Napoleonic era, the Congreve rockets, and the uses of the rocket in the present war for the propulsion of projectiles, for assisting the take-off of aircraft, and as the motive power of aircraft. The rudimentary experiments of the German and the American rocket societies are discussed at some length and due weight is given to the pioneer work of Goddard and of several German experimenters.

The elementary theory back of all this is presented briefly and so incompletely as to give the reader a false idea as to rocket potentialities. For example, a table is given of theoretical jet velocities obtainable from various fuels—a factor of major importance in determining possible rocket velocities. The tabulated jet velocities are obtained by the simple process of equating the kinetic energy of the jet to the heat of combustion of the fuel. The objections to this procedure cannot be detailed here, but the results obtained from it are entirely misleading. Or again, it is stated that the changing size and shape of the combustion chamber in a rocket is a factor in determining its performance. Actually it has no influence so long as there does not result a change in the area of the reacting surface, as is the condition in a modern rocket using an extruded solid propellant.

The terminology of rockets is in process of being established and it is important that

care should be taken in this matter by the writers of early books. The reviewer finds himself at variance with the author as to a number of the terms which he employs. In the title and in the text "Rocket Power" is used quite unjustifiably. The title should be "The Coming Age of Rockets." We do not speak of the present as the age of automobile power or the age of airplane power, but rather as the age of the automobile or the airplane.

Then again, jet propelled craft operating without compression are described as having either "intermittent duct engines" or "continuous duct engines." Apart from the uncertainty as to whether it is the duct or the engine that is either intermittent or continuous (a problem similar to that found in menus on the matter of half-broiled chicken or half broiled-chicken), the fact that the operation occurs in a duct is not fundamental —the same procedures can be carried out in structures of a form that no one would call a duct. In fact, the Karavedine engine—the earliest precursor of the "intermittent duct engine"—has no resemblance to a duct.

The play of fantasy permeates most of the book. While atomic energy as a source of power is dismissed as something for the distant future, such sources of energy as liquid monatomic hydrogen and liquid ozone are given more serious attention. The rocket as a commercial device for the transportation of mail and freight is pictured as a development of the relatively near future. A chapter is devoted to journeys to the moon but without any optimism as to their realizability.

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PHILOSOPHICAL THOUGHTS ON SCIENCE

The Romance of Existence. Ross Bundy. 188 pp. Illus. 1944. $2.00. The Pitman Publishing Corporation, New York, Chicago.

THIS volume is a pungent treatise of philosophical reflections concerning scientific knowledge of the physical universe, particularly with respect to our earth and the development of life upon it. This is a tremendous subject, for it brings together the most profound findings of astronomy, geology, physics, chemistry, biology, and even religion. The author delves deeply into fundamental discoveries of science, reflecting upon them in most discerning ways with unique phrases and sentences, and spicing these with a generous use of newly coined words. The book is a mental stimulant for readers who take delight in contemplating the origin of our earth, evolution, and universal law.

In producing this treatise, the author has given us such mental gems as these:

"Leaves in autumn reveal concealed, locked-up colors as they wither away—so do men and women as they return to the elements—illuminative energy has fulfilled its fate and reverted to other functions in the plans of creation."

"The Earth with its lights and shadows of life is outward bound with that wanderlust which first detached it from a diamond cloud of sundust and sent it reeling among the stars. And as it speeds on through the horizonless night shades of the Milky Way—over seas of darkness—a midget race of human species attempts to fathom the realisms of material things, and often those of the spirit, hoping ever for a flight from destiny."

Amid such delightful, thought-provoking passages as these, however, are numerous lengthy, involved sentences which would prove to be work-outs even for an English professor. For example:

"The cosmology that has been developed by modern science in gravitational and electrical fields, upon living protoplasm and organisms, on mind and matter, the Soul, on heredity and genes, over the mechanics of being, and the origin and evolution of life on Earth are summarized by the intellect of the scientist in the resonant and tremendous philosophical retrospection of faded ag s, the neoversions of brilliant centuries, and the most recent conclusions of man undulating through the misty clouds of fact, fancy and romance." (pp. 120–121.)

The preface of the volume is misleading, for it claims the book to be "the story of our world—of its Geology and Natural History." It should not be called a story, for it is not that. Rather, its chapters are a series of essays and treatises, unsequential, rambling, and more or less unrelated; they are conducive to mental contemplation of the mysteries of Time and Space, Life and Death. To appreciate fully the philosophies

of science, the reader must have more than a passing acquaintanceship with the various physical and biological sciences; and if he has this, he will discover a number of errors, misstatements, outmoded beliefs, and misspelled words, as well as theories and opinions which are presented as facts. A few may be cited:

The author states that the moon does not turn on an axis and presents only one side to the sun (p. 31); he gives the impression that there are only eight planets (p. 15); and believes that the interior half of the earth is a molten mass (pp. 23, 24, 35. 181). Regarding fossils, he indicates that the mastodon became extinct in the Pliocene Epoch (p. 91), gives the impression that complete fossil skeletons and vestiges are unknown from rocks older than the Tertiary Period (p. 63), and uses the word "equestrians" for an order of Coal Age plants (p. 109). Apparently he does not know that man has penetrated, by means of shafts and wells, to depths much greater than 6000 feet (p. 13). Among the misspelled words are "planetismal" (p. 15) for *planetesimal*, and "cyclad" (pp. 53, 109) for *cycad*. Probably the most conspicuous errors occur in respect to the relative ages of the geologic eras, periods, and epochs. According to the author, the Cretaceous Period and the Age of Dinosaurs are distant by 30,000,000 years (pp. 1, 28); yet the Cenozoic Era, which follows the Cretaceous, began 60,000,000 years ago (p. 88). He indicates, also, that the Silurian Period is distant by 130,000,000 years (p. 72); but the Devonian, which follows the Silurian, is over 500,000,000 years away (p. 105)! Other errors and inconsistencies occur with respect to the ages, but it would be superfluous to detail them. Although a few millions of years, more or less, are of little consequence in the enormous magnitude of geologic time, there is no excuse for jumbling them into abnormal superposition.

In spite of inaccuracies such as these, the advanced reader may well find the book to be, as the publishers suggest, "a mental banquet." Certainly he will be drawn to a contemplation of two stupendous, opposing philosophies concerning the nature of our earth: "Living, and even Mind may be but cosmic accidents (p. 187); or, "In a lonely corner of the universe the Earth and its life may yet be but passing phases in the schemes of a greater Mind beyond" (p. 183).

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COMMENTS AND CRITICISMS

"When the Comet Struck America" vs. "Neptune's Racetracks"

The April number contains a very readable fantasy by Dr. C. Wythe Cooke, Senior Geologist, U. S. Geological Survey and Editor of the *Journal of Paleontology*. The purpose of his article is to refute the theory of extraterrestrial bombardment as the explanation of the origin of the parellel, elliptical "bays" of the Carolina coast by the substitution of his own hypothesis.

Briefly, Dr. Cooke states that the land rose, exposing a plane covered with ponds of various shapes and sizes. A strong, steady wind blew from the glacial ice sheet and struck the surface of these ponds. Where the waves struck a shore obliquely, a long-shore current was produced. There had to be a reverse current to stabilize the surface. This returned along the opposite shore, completing the rotation. In case two currents were started, they met at the far end of the pond and returned up the middle, building a dividing sandbar at they came. In the first case there existed a whirlpool turning in one direction; in the second there were two whirlpools turning in opposite directions, but in the same pond. These whirlpools took on the properties of a gyroscope which, considered in connection with the latitude, determined the direction of the long axes of the ponds. No duplication of this phenomenon is known throughout the earth. He submits three excellent aerial photographs which refute his theory.

Has anyone ever seen water whirling in a pond due to wind action? Can anyone produce such a phenomenon in a laboratory? I asked Dr. Cooke these questions. He replied that he had never made laboratory experiments on the shape of eddies because he did not have access to the necessary facilities, but that he had actually seen water rotating in a lake in Florida. At least: "The water must have been rotating, either as a whole or in eddies; otherwise the water would have piled up, and its surface would not have remained in equilibrium."

Apparently Dr. Cooke overlooks certain facts: wind acts on the *entire* surface of a pond; water does pile up at the far end to a limited extent, and the return flow is subsurface—not a return surface current of rotation; the ponds have to be approximately the shape that he tries to account for in order to have any currents. Take, for example, a triangular pond with one of its angles facing the wind; obviously no long-shore current could result since there would be no oblique shores for the waves to strike. The photographs show no exceptions; every pond apparently was perfect for the accomplishment of his theory. I asked the Dr. if, as he states, the returning central current could build a sandbar which would make two ponds where one had existed before, why would not this repeat, resulting in numerous long ponds. His answer was:

"I suppose that a long-continued eddy would tend to split up into smaller eddies. In fact, Figure 2 of 'Neptune's Racetracks' shows four well-defined ellipses that probably originated in this way. However, this process of splitting would not continue indefinitely, for the gyroscopic action continues only so long as the wind blows, and the current continues to flow. Moreover, the splitting is opposed by the inertia of the moving water."

Look at the photographs. The ponds could not have been of various shapes—they were all suitable for forming elliptical ponds. If Figure 2 shows four ponds that were made by the division of one, why are there large ponds that have not divided at all, as shown in Figures 1 and 3? If you consider that the four ponds shown in Figure 2 had originally been one, the shape would preclude rotation; also the bar separating the two center ponds should be wider since this would have been the primary division. This is opposite to what the photograph shows. Ponds produced by splitting should be of equal length. These outer ponds are shorter than their supposed twins. He stated that ponds would not continue dividing because: ". . . the gyroscopic action continues only so long as the wind blows, and the current continues to flow." His original hypothesis does not mention gyroscopic action in connection with the formation of the ellipses, but merely in their *direction*. If the wind blew long enough to form the four ponds of Figure 2, then why was a similar result absent in the large ponds shown in Figures 1 and 3? There is no indication of any partially built dividing bar in any of the photographs.

There is no object in going into the gyroscopic phase of his hypothesis other than to mention that he says in his letter: "Strictly speaking, I suppose it is improper to call this effect gyroscopic. . . ." He is unable to give any reason why the water should have revolved or even how it would be possible to reproduce such a miracle in a laboratory.

Wind striking a pond does not cause the water to rotate. Dr. Cooke's entire hypothesis is based on a fallacy.—CHAPMAN GRANT.

We accepted the "readable fantasy" by Dr. Cooke not knowing that we were to become involved in a scientific controversy. When Major Grant, a herpetologist, took issue with Dr. Cooke, a geologist, on a geological question, we put our hypothetical money on the latter. But the Major was undaunted; he came up with a brand-new hypothesis of his own, which, contrary to our own rules, we expect to publish in the SM.—ED.

THE BROWNSTONE TOWER

THE time and place are not important, but because of other circumstances I remember that Mr. Christensen's proposal was made on February 10, 1945, about 1 P.M., as he and Dr. Moulton and I were walking along Twelfth Street under the semicircular colonnade of the Post Office Department. We were returning to the Smithsonian after lunch —the last I was to have downtown for many a day. As our banter ceased, Mr. Christensen became serious and popped a question that had long been on his mind. "Would you like me to become book review editor of the SM?" he asked. "I'd be glad to take the responsibility for getting reviews and preparing them for publication," he added. "Sold!" I exclaimed, and Dr. Moulton agreed. So Mr. Christensen became book review editor of the SM in addition to his duties as advertising manager of *Science* and the SM.

Only four days later I lay on my back suffering from rheumatic fever, one of the sequels of scarlet fever. Spring came and summer was approaching before I saw the brownstone tower again. During those three weary months I wrote "The Brownstone Tower" but did little else for the SM. Dr. Moulton acted as editor and Mrs. Scovill and Mr. Christensen did the rest. Now I want to thank them publicly for their effective work.

Our book-review policy is based on unscientific assumptions. Lacking a Gallup poll, we assume first that book reviews are desired by our readers. Then we assume that we should limit our reviews to books that are similar in character to the contents of the SM; that is, to books that deal with or pertain to science and lie in the popular field between highly technical monographs and elementary textbooks. Finally, we make assumptions on the number, length, and character of the reviews that we should publish each month. As it does not seem feasible to get and publish reviews of all new books that may lie within the scope of the SM, we announce some of them only in the form of brief notices, one or two columns of which are published each month on page iii or iv. These notices are now written by Mr. Christensen.

Most books received for review in the SM are sent to us voluntarily by their publishers, but not all of these seem appropriate for review. Some are merely noticed and others are ignored. Unsolicited books that are not sent out for review are given to the library of the Smithsonian Institution. Few solicited books fail of review; those few are returned to the publishers. Every book reviewed for the SM becomes the personal property of the reviewer.

The quality of our reviews varies at least as much as the quality of the books reviewed. We shun reviewers who give us a dry inventory of contents, who continually gush praise or find fault, or who pay little attention to a book but use it merely as a platform for their sermons; we favor reviewers who pursue a happy medium, disclosing the nature of a book as they comment on it with illustrations drawn from their own knowledge. One of the greatest virtues of a reviewer is promptness. For the author and publisher the value of a review decreases as the interval between publication of the book and its review increases. A reviewer who follows the Golden Rule will return a book if unforeseen circumstances prevent him from reviewing it before the deadline agreed upon. Sometimes while examining a book a reviewer finds himself allergic to it. In such cases we think that the promise to review should be revoked and the book returned to us; another person may not be so affected.

We have never set an inflexible limit to the length of our reviews but we think 1000 well-chosen words ought to be enough to characterize and evaluate a book and that fewer should usually suffice.

We are trying to increase the number of those who review books for the SM, though it is a temptation to send books to the old reliables. The usual complete transaction requires three letters: (1) Will you do it? (2) Thanks for your promise; the book is on the way. (3) Thanks for your review. Item (1) can sometimes be eliminated by an enterprising person who writes: "If the new book by ———— entitled ———— is available and unassigned, I should like to review it for the SM." Letters such as this and all other letters concerning SM book reviews should be addressed to Mr. T. J. Christensen, AAAS, Smithsonian Institution Building, Washington 25, D. C. He is a good man.—F. L. CAMPBELL.